Speculum Nauticum.

A Looking-Glass FOR SEA-MEN.

Wherein they may behold, how by a ſmall Inſtrument, called the PLAIN SCALE, all Nautical Queſtions, and Aſtronomical Propoſitions, are very eaſily and demonſtratively performed.

Firſt ſet forth by JOHN ASPLEY, Student in Phyſick, and Practitioner of the Mathematicks in LONDON.

THE SEVENTH EDITION.

Whereunto are added many new Propoſitions in Navigation and Aſtronomy; and alſo a third Book, ſhewing a new way of Dialling. With an Appendix containing the Uſe of all Inſtruments that are uſed at Sea.

By *H. P.* and *W. L.*

LONDON,
Printed by *W. Godbid* for *George Hurlock*, and are to be ſold at his Shop at St. *Magnus* Church-Corner near *London* Bridge. 1668.

BODLEIANA · BIBLIOTHECA

TO THE

WORSHIPFUL,

THE

MASTER, WARDENS, & ASSISTANTS

OF THE

TRINITY HOUSE;

JOHN ASPLEY,

IN

TESTIMONY OF THE HONOUR

HE BEARS TO THE

GOVERNORS & PRACTISERS

OF THE ART OF

NAVIGATION,

DEDICATES THESE HIS

FIRST LABOURS.

The Stationer to the Reader.

THis little Book having been well accepted of among Sea-men, being the first fruits of Mr. Aſpley's *Mathematical Studies, hath paſſed ſix Impreſſions without any alteration; and ſo I doubt not might have done ſtill: But becauſe ſince that time there have been ſeveral Books put out of this nature, I have procured this to be reviſed, and ſeveral Alterations and Additions to be made therein: So that here you have both the old, and a new Book intermingled all in one, with a third part added thereto, concerning Dialling, by a way not formerly publiſhed by any. All which I doubt not you will kindly accept of, and receive much delight and profit thereby.*

Yours

G. H.

Speculum

Speculum Nauticum,

OR,

THE SEA-MANS GLASS.

The First Book.

CHAP. I.

The Explanation of certain Terms of Geometry.

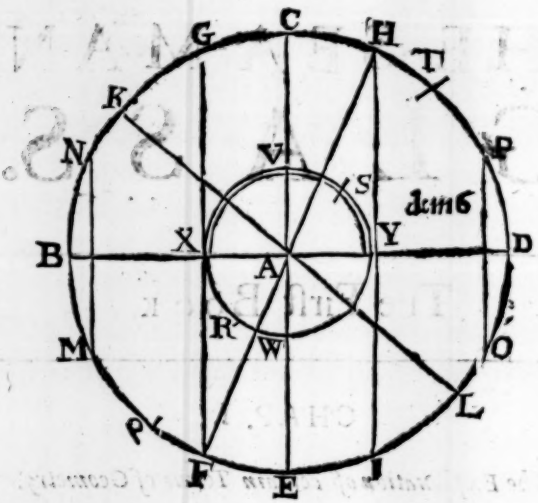
Eing intended in this Treatise of the plain Scale, to declare the manner of projection of the Sphere, *in plano*, I have thought fitting, first to shew unto you some terms of Geometry which are necessary for the unlearned to know, (for whose sake chiefly I write this Treatise) before they enter into the definition of the Sphere.

First therefore I intend to relate unto you, what a Point or Prick is,

and afterward a Line both right and crooked, and ſuch ſorts thereof as are appertinent unto the operations and uſe of this Scale.

Punctum, or a Point, is the beginning of things; or a Prick ſuppoſed indiviſible, void of length, breadth, and depth: as in the Figure following is noted by the point or prick A.

Linea, or a Line, is a ſuppoſed length, or a thing extending it ſelf in length, not having breadth nor thickneſs, as is ſet forth unto you by the Line B A D.



Parallela, or a Parallel Line is a Line drawn by the ſide of another Line, in ſuch ſort that they may be equidiſtant in all places. And of ſuch parallels, two onely belong unto this work of the plain Scale, that is to ſay, the right lined Parallel, and the circular Parallel.

Right lined Parallels are two right lines equidiſtant one from another, which being drawn forth infinitely, would never touch or meet one another, as you may ſee in the Figure, where the line H I is parallel unto the line C E, and the line G F is parallel unto them both.

A circular Parallel is a circle drawn either within or without another circle upon the ſame center, as you may ſee plainly by the two circles B C D E, and X V Y W. Theſe circles are both drawn upon the center A, and therefore are parallel the one unto the other. There is another kind of Parallel alſo, which is called a Serpentine Parallel, but becauſe it is not belonging unto the uſe of this Scale, I will omit it, and ſo proceed unto the reſt.

Perpendiculum, or a Perpendicular, is a line raiſed from, or let fall upon another line, making equal Angles on both ſides, as you may ſee declared in the Figure, wherein the line A C is perpendicular unto the line B A D, making equal angles in the point A.

Diameter circuli, or the Diameter of a Circle, is a right line drawn thorow the center of any circle, in ſuch ſort that it may divide the circle into two equal parts, as you may ſee the line B A D is the Diameter of the circle B C D E, becauſe it paſſeth thorow the center A, and the two ends thereof do divide the circle into two equal parts in the two extreams B and D, making the ſemicircle B C D equal unto the ſemicircle D E B.

Semidiameter circuli, or the Semidiameter of a circle, is half of the Diameter, and is contained betwixt the center, and the one ſide of the circle, as the line A D is the Semidiameter of the circle B C D E. This Semidiameter contains 60 degrees of the line of Chords, which we ſometimes call the Radius.

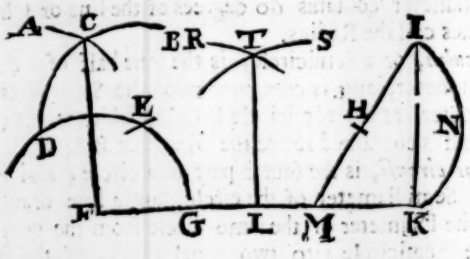
Semicirculus, or a Semicircle, is the one half of a circle drawn upon his Diameter, and is contained upon the Superficies or Surface of the Diameter, as the Semicircle B C D, which is half of the circle B C D E, and is contained above the Diameter B A D.

Quadrans circuli, is the fourth part of a circle, and is contained betwixt the Semidiameter of the circle, and a line drawn perpendicular unto the Diameter of the ſame circle from the center thereof, dividing the Semicircle into two equal parts, of the which parts the one is the Quadrant, or fourth part of the ſame circle. As for example, the Diameter of the circle B C D E is the line B A D, dividing the circle into two equal parts: then from the center A raiſe the perpendicular A C, dividing the Semicircle likewiſe into two equal parts; ſo is A B C, or A C D, the Quadrant of the circle B C D E, which was deſired.

CHAP. II.

The manner how to raiſe a Perpendicular from the middle of a line given.

DRaw firſt a ground line whereupon you would have a Perpendicular raiſed, then open your Compaſſes unto any diſtance (ſo it exceed not the end of your line,) placing one foot of the ſaid Compaſſes in the point from whence the Perpendicular is to be raiſed, and with the other foot make a mark in the line on both ſides, then removing your Compaſſes unto any other diſtance that is greater, ſet one foot thereof in one of the marks, and with the other foot make an arch over the middle point; then with the ſame diſtance of your Compaſſes ſet one foot in the other mark upon the line, and with the other foot make another arch of a Circle over the middle point, ſo that it may croſs the firſt arch; and from the meeting of theſe two arches, draw a right line unto the middle point, from which the Perpendicular was to be raiſed, which line ſhall be the Perpendicular deſired.



Example. Suppoſe your baſe or ground line whereupon a Perpendicular is to be raiſed, be the line F L K, and from L the Perpendicular is to be raiſed, ſet one foot of your Compaſſes in the point L, and with the other make the marks G and M on both ſides of the point L; then opening your Compaſſes wider, ſet one foot in the point M, and with the other draw the arch S over the point L, then

then with the ſame diſtance of your Compaſſes, ſet one foot in G and with the other make the arch R, croſſing the arch S in the point T, then from T draw the line T L, which line is perpendicular unto the line F L K from the point L, which is the Perpendicular deſired.

CHAP. III.

To let a Perpendicular fall from any Point aſſigned, unto the middle of a line.

LEt the line whereupon you would have a Perpendicular let fall, be the line L F K, and the point aſſigned to be the point T, from whence you would have a perpendicular let fall upon the line F L K; firſt ſet one foot of your Compaſſes in T, and open your Compaſſes unto any diſtance, ſo that it be more than the diſtance T L, which here we ſuppoſe to be the diſtance T M; then make in the line F L K, the marks G and M, then with your Compaſſes take the one half of G M, which is the point L, then from L draw a line unto the point T, ſo the line T L ſhall be the Perpendicular which was deſired to be let fall from the aſſigned point T, unto the middle of the line F L K.

CHAP. IV.

To raiſe a Perpendicular upon the end of a Line.

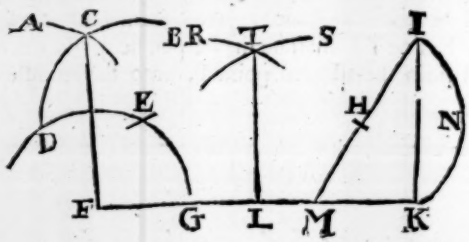
SUppoſe the line whereupon you would have a Perpendicular raiſed, be the line F L K, and from the point F a Perpendicular is to be raiſed: firſt open your Compaſſes unto any diſtance, which here we put to be the diſtance F G, and ſet one foot of your Compaſſes in the point F, and with the other draw the arch D E G, then ſet one foot of your Compaſſes in the point G, and with the other draw the arch E; then placing one point of your Compaſſes in E, with the other draw the arch D B; then place your Compaſſes

Compaſſes in D, and with the ſame diſtance draw the Arch A, cutting the Arch D B in C, then draw a line from C unto the end of the line F L K, unto the aſſigned point F, ſo ſhall the line C F be a perpendicular raiſed from the end of the line F L K, and from the aſſigned point F.

CHAP. V.

To let a Perpendicular fall from any point aſſigned, unto the end of a Line.

LEt the line F L K be the Baſe or ground line, and from the point I a perpendicular is to be let fall upon the end of the line at K, firſt from the aſſigned point I, draw a line unto any part of the Baſe, which ſhall be the line I H M, then find the middle of the line I M, which is at H; place therefore one foot of your Compaſſes



in the point H, and extend the other unto I, with which diſtance draw the Arch I N K upon the Center H, cutting the Baſe or ground line in the point K, then draw the line K I, which line ſhall be the Perpendicular deſired.

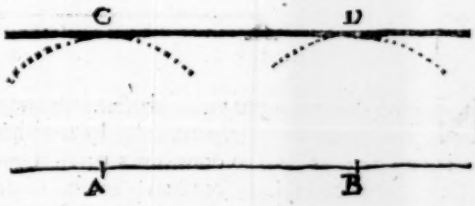
CHAP.

CHAP. VI.

A right line being given, how to draw another parallel thereunto at any diſtance required.

LEt the line given be A B, unto which it is required to draw another right line C D which ſhall be parallel to the former line A B, and at the diſtance A C.

Firſt open your Compaſſes to the diſtance A C, then ſet one foot in the point A, with the other deſcribe the Arch C; Again, place one foot in B, and with the other deſcribe the Arch D; Then draw the line C D, ſo that it may only touch the two Arches C and D, ſo ſhall the line C D ſo drawn, be parallel to A B, and at the diſtance required.



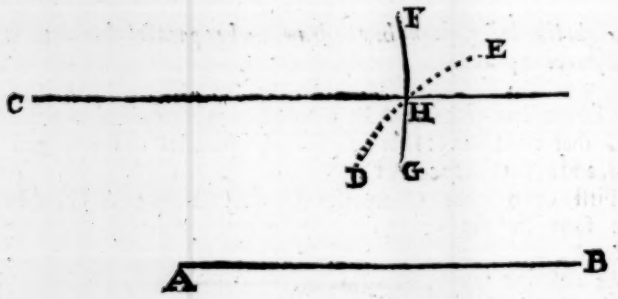
CHAP. VII.

A right line being given, how to draw another parallel thereunto, which ſhall alſo paſs through a point aſſigned.

LEt A B be a line given, and the point aſſigned be C: and let it be required to draw another line parallel thereunto, which ſhall paſs through the given point C.

Firſt, Take with your Compaſſes the diſtance from A to C, and placing one foot thereof in B, with the other deſcribe the Arch D E, then take in your Compaſſes the whole line A B, and placing one foot

foot in the given point C, with the other foot deſcribe the arch F G, croſſing the former arch D E in the point H. Laſtly, If you draw the line C H, it ſhall be parallel to A B.



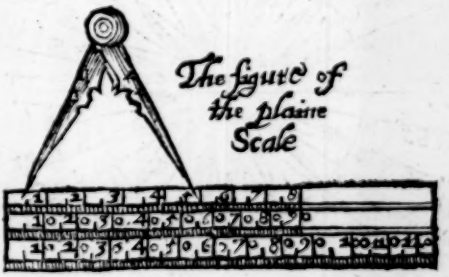
NOw I doubt not but you underſtand the way to let fall or to raiſe any manner of Perpendicular line, either from, or upon any part of a line; as alſo to draw lines parallel one to another at any diſtance required: therefore now I intend to proceed unto the main point here aimed at, which is, to declare and make known unto you the ſeveral operations performed by the plain Scale, which though it be in uſe with very few, yet it is moſt neceſſary for Sea-men, becauſe all queſtions in Navigation are thereby eaſily and plainly wrought. And alſo all queſtions in Aſtronomy (belonging unto the expert and induſtrious Sea-men) may both ſpeedily and eaſily be wrought by the ſame Scale: in regard whereof I have declared in this little Book that knowledge (which God hath been pleaſed to beſtow upon me) concerning the neceſſary uſe and practice thereof; hoping that you will as kindly accept it, as it is freely offered unto your courteous conſiderations.

CHAP.

CHAP. VIII.

Of the Diſcription of the Scale.

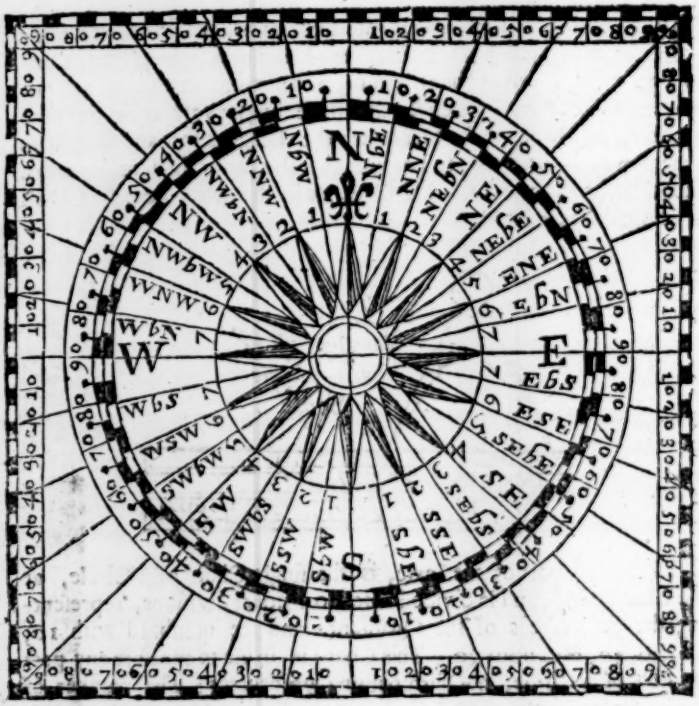
THis Scale uſually is divided into three parts, the firſt whereof is a Scale of equal parts, divided into Miles or Leagues, from 1 unto 100 and upwards at your pleaſure, and numbred with 10, 20, 30, 40, and ſo forth unto the end. All theſe diviſions are equal one unto another, and is in uſe for to meaſure the Leagues that any Ship hath run upon any courſe, or the Leagues that ſhe hath raiſed or depreſſed the Pole, or departed the Meridian, as in the work hereafter ſhall be more fully declared.



The ſecond part of the Scale, is the ſingle Chord of a Circle, or the Chord of 90, and is divided into 90 unequal diviſions, repreſenting the 90 degrees of the Quadrant: and are numbred with 10, 20, 30, 40, &c. unto 90. This Chord is in uſe to meaſure any part or arch of a Circle, not ſurmounting 90 degrees: The number of theſe degrees from 1 unto 60 is called the Radius of the Scale, upon which diſtance all circles are to be drawn, whereupon 60 of theſe Degrees are the Semidiameter of any Circle that is drawn upon that Radius.

The third part of the Scale is divided into eight parts, repreſenting the Points or Rumbs of the Mariners Compaſs; which in all

are 32 points: but upon the Scale there are only 8 reckoned, which is but one Quadrant or quarter of them, being to be reckoned from the Meridian of North and South both ways, as you may ſee more plainly by this Figure, repreſenting the order of the points of the Compaſs.



It is uſual alſo to have another line placed upon your Scale, to ſhew you how many leagues make a degree of longitude in every latitude; Concerning which you ſhall have directions in the 14 Chapter following.

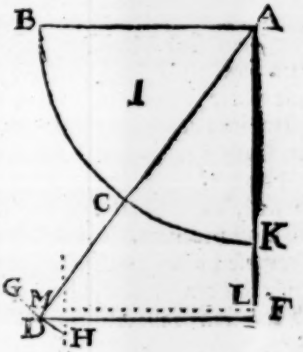
CHAP.

CHAP. IX.

Knowing the courſe any Ship hath made, and the leagues ſhe hath ſailed: to find how much ſhe hath raiſed or depreſſed the Pole: and likewiſe how much ſhe is departed from her firſt Meridian.

The Courſe is South-weſt and by South, the Leagues ſailed are 100, *the difference of the Latitude, and the diſtance of the Meridians is required.*

IN the firſt demonſtration, firſt draw the line A B, and from the center A, let fall the perpendicular A F, which repreſents the Meridian; then opening your Compaſſes unto the Radius of your Scale, ſet one foot thereof in the Center A, and with the other draw the arch KCB: then in regard your Courſe is South-weſt and by South, that is 3 points from the South, take three of the eight points of the Compaſs with your Compaſſes out of your Scale, and place them from K to C; then draw the line A C D, which repreſents the Rumb or point of the Compaſs you have ſailed upon; then cut off your Scale of leagues, take with your Compaſſes the number of leagues you have ſailed upon this courſe, which is 100 leagues, and place them upon the Rumb line A C D, from A to D, croſſing the line A C D at the end thereof with the arch G D H: then from the point D, draw the line D F parallel to the line A B, ſo it will cut the Meridian line A K F in the point F.



Now you muſt heedfully obſerve this point D, for this repreſents the place where your Ship is, and doth ſhew both the difference of the latitude of the place you are in, and alſo your diſtance or departure from your firſt Meridian.

Firſt for the latitude, You ſee the line D F, being parallel to the

line A B, cuts the Meridian line A F in the point F: So that if you take the diſtance F A with your Compaſſes, and apply it to the ſcale of equal leagues, you ſhall find it is juſt 83 leagues, which counting 20 leagues to a degree, makes 4 degrees 9 min. and ſo much you have altered your latitude by the ſaid courſe; which degrees and minutes being added to, or ſubſtracted from the latitude of the place you came from, according as your courſe requires, ſhews you always the true latitude you are in.

Likewiſe from this point D, take with your Compaſſes the diſtance D F, and you ſhall find it by your ſcale of equal leagues to be 56 leagues; and ſo much you are departed from your firſt Meridian to the Weſtward: which when you are near the Equinoctial, where the degrees of longitude are equal to the degrees of latitude, would ſhew the longitude, by taking 20 leagues for one degree, &c. ſo it would be two degrees and 48 min. for your difference of longitude from your firſt Meridian A F. But in other places you muſt firſt learn how many leagues make a degree of longitude about that latitude where you are, and ſo turn your leagues of diſtance from the Meridian, into degrees and minutes of longitude; of which more hereafter, Chap. 14.

I have been the larger in theſe two Propoſitions, becauſe they are the firſt, for the better underſtanding of all the reſt; and becauſe they are moſt neceſſary, for thereupon depends the knowledge of the true Traverſe point, and the keeping of your dead reckoning. Now becauſe this cannot always be kept exactly, it is to be corrected by the obſervation of the latitude, according to this following propoſition.

CHAP.

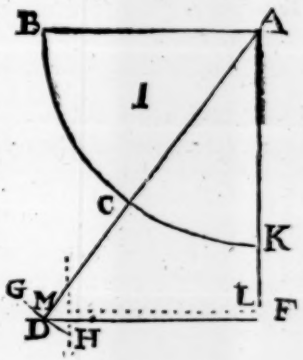
CHAP. X.

Knowing the difference of latitude of two places, and the Rumb you have ſailed upon, to find the leagues you have ſailed, and the difference of Meridians.

The Pole depreſſed four degrees, and the Rumb South-weſt by South, or the third from the Meridian, to find your true Traverſe point, viz. *how far you have ſailed, and how much you are departed from your firſt Meridian.*

In the firſt Figure.

DRaw the lines as in the former Chapter, ſo that A K F may repreſent the Meridian line, and A C D may repreſent the third Rumb from the Meridian; then becauſe you have altered your latitude 4 degrees, which make 80 leagues, take 80 leagues with your Compaſſes out of your ſcale, and ſet them upon the Meridian line A F, from A to L: Then keeping the ſame diſtance of your Compaſſes, draw the line L M parallel to A B, (or elſe you may erect L M perpendicular to the line AF, in the point L) and mark where the ſaid L M croſſeth the Rumb line ACD, which is in the point M. This point M is the true Traverſe point, the leagues ſailed are ſhewed by the line A M, which being meaſured in the ſcale, will be found to be 96 leagues and an half, and the departure from the Meridian is L M, which is 54 leagues.



Now by this Propoſition (as I ſaid) you may correct your dead reckoning; for ſuppoſe by the former propoſition you reckon you had ſailed 100 leagues upon the third Rumb, then as you ſee there you ſhould have been at the point D, and have altered your latitude

83 league

83 leagues, and departed from your Meridian 56 leagues; but now ſuppoſe that by a good obſervation of the latitude, you find that you have altered the latitude only 80 leagues from A to L, by drawing the line L M, which croſſeth the Rumb or Ships way in M, you may conclude your true traverſe point to be at M, ſo that you have ſailed only from A to M, which is 96 leagues $\frac{1}{2}$, and departed from your Meridian 54 leagues. So that as you are ſhort of the latitude you reckoned for, 3 leagues or 9 min. you are alſo ſhort of your way you reckoned, 3 leag. $\frac{1}{2}$, and 2 leagues leſs in your departure from the Meridian. And this you muſt account for your true reckoning, being thus corrected.

CHAP. XI.

By the difference of the latitudes of two places and the diſtance between their Meridians, to find the Rumb by which you muſt ſail from the one place to the other, and how far it is from the one place to the other.

The difference of latitude between the two places is 4 deg. 9 min. and the diſtance between the two Meridians is 56 leagues, and it is required to find the Rumb from the one place to the other.

IN the former Figure draw the Quadrant A K C B, then turn your four degrees 9 min. of latitude into leagues, it maketh 83 leagues, which you muſt place upon the Meridian line from A to F. And from the point F draw the line F D parallel to the line A B. Then open your Compaſſes to the diſtance of the Meridians, which is 56 leagues, and ſet it on the line F D, from F to D. Then lay your Ruler by this mark D and the center A, and draw the line A C D. Then mark where this line cuts the quadrant, which is in the point C, and ſetting one foot of your Compaſſes in the point C, open the other to K, and keeping your Compaſſes at that diſtance C K, meaſure it upon your Scale, either in the line of Chords, or in the line of Rumbs, you ſhall find it to be in the one 33 deg. 45 min. and in the other, juſt the third Rumb from the Meridian. So that the Rumb from A to D is South-weſt and by South, and the Rumb from D to A is the Rumb oppoſite thereunto, which is North-eaſt and by North.

Then

Then for the diſtance between the two places in the Rumb, ſet one foot of your Compaſs in the one place at A, and open the other to the other place at D, and the length of the line A D meaſured in the Scale of leagues, ſhews the diſtance between them to be juſt 100 leagues.

Theſe three (or rather theſe ſix) Propoſitions, (for they are each of them double) are the moſt uſeful and neceſſary in the art of Navigation. By the firſt of theſe, knowing the point of the Compaſs you ſail upon, and judging how many leagues you have ſailed thereon, you know and are able to give a reaſonable account where you are, both in reſpect of latitude and longitude. By the ſecond, having a fair obſervation of the latitude at any time, you may more perfectly know where you are; and thereby correct your former account. And by this third you may know how to direct your courſe from any place to your deſired Haven. So that in effect you need no more, but yet for your better inſtruction by variety of caſes and examples, I ſhall proceed.

CHAP. XII.

The difference of latitude and the leagues ſailed being given, to find the diſtance from the Meridian, and the Rumb you have ſailed upon.

Sailing 100 *leagues between South and Weſt, until the Pole be depreſſed* 4 *deg.* 9 *min. the diſtance from the Meridian is demanded, and what Rumb you have ſailed upon?*

IN the firſt figure draw the Quadrant A K C B, as in the former chapters, and then reduce your degrees of latitude into leagues, ſo 4 deg. 9 min. make 83 leagues, which you muſt take with your Compaſſes out of your Scale of leagues, and ſet them off in this Meridian line from A to F. Then from the point F draw the line F D, parallel to the line A B, which you may do with the foreſaid diſtance of your Compaſſes. Then open your Compaſſes unto your diſtance ſailed, which is 100 leagues, and ſetting one foot of your Compaſſes in the point A, with the other draw the little

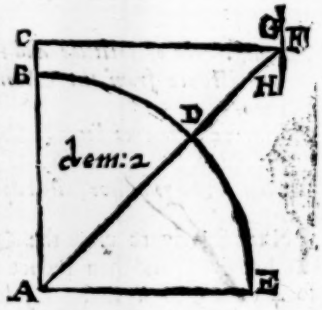
arch

arch H G, cutting the line F D in the point D. So the line F D meaſured in the ſcale of leagues, ſhall ſhew you the diſtance from the Meridian, which is 56 leagues; and if you draw the line A C D, it is the Rumb-line upon which you have ſailed, and the arch K C meaſured in the ſcale of Rumbs, ſhews it to be the third Rumb from the Meridian, or South-weſt by South.

CHAP. XIII.

To find the diſtance of any Iſland from you, that you may diſcern at two ſtations, knowing the point of the Compaſs, the Iſland beareth unto each of the ſtations.

Suppoſe, being at Sea you diſcover an Iſland bearing North-eaſt off you, which place let it be your firſt ſtation, and then ſailing ſeven leagues full North, you obſerve the Iſland to bear full Eaſt off you, which let be the ſecond ſtation; the demand is to find the diſtance of the ſaid Iſland from both the ſaid ſtations?



IN the ſecond Figure, or demonſtration, let A be the firſt Station, and upon the Center A draw the Quadrant A B D E; Then in regard you found the Iſland to bear North-eaſt from you, take four of your eight points of the Compaſs out of the ſcale, and place them upon your Quadrant from B to D, then from the Center A by the point D, draw the line A D F, repreſenting the viſual line paſſing between your ſight and the Iſland, being at the firſt ſtation A. Then ſeeing when you had ſailed 7 leagues North, you obſerved the Iſland to bear full Eaſt off you, ſet off the ſaid ſeven leagues from A to C, (reckoning every 10 leagues of your ſcale to be but one) and from this point C, which is the ſecond ſtation, draw the line C F parallel to

to A E, and it will cut the line A D F in the point F: ſo ſhall the point F be the place of the Iſland deſired, and the diſtance A F, is the diſtance of the Iſland from the firſt ſtation, *viz.* 9 leagues 90 parts or almoſt 10 leagues: Likewiſe the diſtance from C to F is the diſtance of the Iſland from the ſecond ſtation, which is juſt ſeven leagues. And by this manner of work, you may find the diſtance of any Iſland or head land from you, or you may take the diſtances of as many places as you will or can ſee at any two ſuch ſtations, and by the croſſing of their viſual lines, find their poſition and diſtances each from other.

CHAP. XIV.

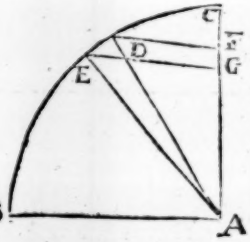
To find how many leagues, miles, and parts do make one degree of longitude in every latitude.

Note, *All this while we have been ſailing according to the Rules of the plain Chart, which ſuppoſeth the degrees of longitude to be equal to the degrees of latitude, in all latitudes, but that is very falſe and erroneous; it being true only in places near the Equinoctial, where every degree of longitude contains 20 leagues, as the degrees of latitude do; But in places near the Poles it alters very much, ſo that in the latitude of 60 degrees, 10 leagues make a degree of longitude: and in other latitudes the degrees of longitude alter, as in this little Table, which ſhews at what degree and minute of latitude any number of leagues make a degree of longitude, by which you may divide a Line upon your Scale for your ready uſe.*

Leagues in one Degree.	20 00d	00 m	Leagues in one Degree.	10 60d	00 m
19	18	11	0	63	15
18	25	50	8	66	25
17	31	47	7	69	31
16	36	52	6	72	32
15	41	25	5	75	31
14	45	34	4	78	28
13	49	27	3	81	22
12	53	08	2	84	16
11	56	38	1	87	08

Now to return to the Queſtion, and ſhew you by demonſtration how to find how many leagues, miles, and parts, make a degree of longitude in any degree of latitude?

TAke 60 parts out of your Scale of equal parts, which you muſt reckon for miles, and count three of them to a league, and therewith draw the quadrant A B C, then from the point B, ſet off the degree of the latitude propoſed (which for example, let it be 58 deg. 54 m.) from B to D, then from the point D draw the line D F parallel to A B, ſo ſhall the length of this line DF, being meaſured in your ſcale of leagues, ſhew you the number of leagues and miles, which anſwer to a degree of longitude in the ſaid latitude of 58 deg. 54. min. which you ſhall find to be 31 miles, or 10 leagues and one mile. So alſo B E being the arch of 51 deg. 55 min. the line E G ſhews one degree of longitude to be 37 miles, or 12 leagues and one mile.



The larger you make your Quadrant, the more exactly will the work be, and ſhew the leagues and miles more exactly, which you may make into a Table, as this following.

A Table

A Table ſhewing how many leagues, miles, and hundred parts of a mile make one degree of longitude in any latitude.

Latitude	Leagues	Miles	Parts	Difference
0	20	0	0	1
1	19	2	99	3
2	19	2	96	4
3	19	2	92	7
4	19	2	85	8
5	19	2	77	10
6	19	2	67	12
7	19	2	55	13
8	19	2	42	16
9	19	2	26	17
10	19	2	09	19
11	19	1	90	21
12	19	1	69	23
13	19	1	46	24
14	19	1	22	26
15	19	0	96	28
16	19	0	68	30
17	19	0	38	32
18	19	0	06	33
19	18	2	73	35
20	18	2	38	37
21	18	2	1	38
22	18	1	63	40
23	18	1	23	42
24	18	0	81	43
25	18	0	38	45
26	17	2	93	47
27	17	2	46	48
28	17	1	98	50
29	17	1	48	52
30	17	0	96	53
31	17	0	43	55
32	16	2	88	56
33	16	2	32	58
34	16	1	74	59
35	16	1	15	61
36	16	0	54	62
37	15	2	92	64
38	15	2	28	65
39	15	1	63	67
40	15	0	96	68
41	15	0	28	69
42	14	2	59	71
43	14	1	88	72
44	14	1	16	73
45	14	0	43	75
46	13	2	68	76
47	13	1	92	77
48	13	1	15	79
49	13	0	36	79
50	12	2	57	81
51	12	1	75	82
52	12	0	94	83
53	12	0	11	84
54	11	2	27	86
55	11	1	41	86
56	11	0	55	87
57	10	2	68	88
58	10	1	80	90
59	10	0	90	90
60	10	0	0	91
61	9	2	09	92
62	9	1	17	93
63	9	0	24	94
64	8	2	30	94
65	8	1	36	96
66	8	0	40	96
67	7	2	44	97
68	7	1	47	97
69	7	0	50	98
70	6	2	52	99
71	6	1	53	99
72	6	0	54	100
73	5	2	54	100
74	5	1	54	101
75	5	0	53	101
76	4	2	52	102
77	4	1	50	102
78	4	0	48	103
79	3	2	45	103
80	3	1	42	104
81	3	0	38	103
82	2	2	35	104
83	2	1	31	104
84	2	0	27	104
85	1	2	23	105
86	1	1	18	104
87	1	0	14	105
88	0	2	09	104
89	0	1	05	105
90	0	0	0	

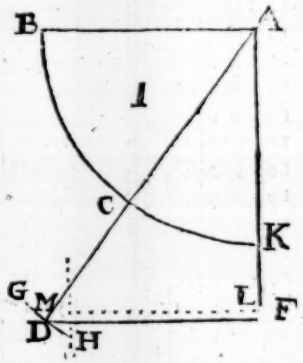
CHAP. XV.

The difference of latitude, and the Rumb or diſtance ſailed being known, to find the diſtance of the Meridians, and thereby to find the degrees and minutes of the difference of longitude in any latitude.

Sailing from the North Parallel of 56 degrees and 5 min. latitude, 100 leagues upon the third Rumb from the Meridian, viz. South-weſt and by South, until I find the Pole is depreſſed 4 degrees 9 minutes, and the Meridional diſtance 56 leagues; the longitude is deſired thereby?

In the firſt Figure.

DRaw the quadrant as is ſhewed before, then reduce your 4 degrees 9 min. of latitude into leagues, it makes 83 leagues, which ſet off upon the Meridian line from A to F. Then upon the Rumb line A D C ſet off the diſtance ſailed from A to D, and after, by theſe two points, draw the line F D; So ſhall D repreſent the place of the Ship, and as A F is the difference of latitude, ſo F D is the difference of Meridians, which meaſured in your Scale of leagues is 56 leagues.



Now to reduce this 56 leagues into degrees of longitude, you muſt conſider from what latitude you have ſailed, and to what latitude you are come, *viz.* from latitude 56 d. 5 m. to 4 deg. 9 min. leſs, which is 51 d. 56 m. and take the middle latitude or (ſomewhat more) between the two places, which in this example falls out to be 54 d. 01 m. Then by the Table in the former Chapter, find out how many leagues and miles in the ſaid middle latitude make one degree

degree of longitude, and you ſhall find in that Table, that in the latitude of 54 d. there is but 11 leagues, and 2 miles, and 27 parts in one degree of longitude, Therefore open your Compaſſes upon your Scale of leagues, to this 11 leagues, 2 miles, 27 parts, and keeping your Compaſſes at that diſtance, ſet one foot of them at 56 leagues in your Scale of leagues, or in the line D F in the figure, (or upon the like line in your Chart at any time) either at F or D, and meaſure how many times you find that diſtance either to the end of your Scale coming backward, or in the line D F, for ſo many degrees is the difference of longitude; and if any odd part remain, you may proportion it by your eye, judging it to be a quarter, a third, an half, or any part more or leſs of a degree, which you may either reckon by parts, or 15, 20, 30, &c. minutes.

Thus this line D F being 56 leagues, opening your Compaſſes to 11 leagues 2 miles 27 parts, you will find this diſtance in it, 4 times and 3 quarters; ſo that the difference of longitude is 4 deg. 45 min.

Or you may reduce it into miles and work by the rule of proportion, ſo you ſhall find.

As 11 leagues, 2 miles, 27 parts, that is 35 miles 27 parts.	35,27
To one degree of longitude in the latitude of 54 d.	01,00
So is 56 leagues, or 168 miles	168,00
To 4 degrees, 76 parts.	04,76

But if your Scale be large, the other way with your Compaſſes will give you the degrees and parts of longitude as exactly as you need, for moſt uſes.

Alſo if the latitude fall not out in equal parts, you may find out for your odd minutes by proportion; for which purpoſe I have ſet the differences between each degree in the Table.

So that as one hundred parts, or 60 minutes being one degree to the difference in the Table between the two next degrees;

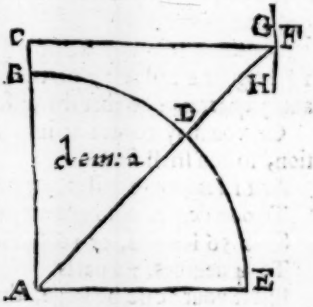
So the odd hundred parts or minutes of latitude, to the parts and minutes proportional to be allowed.

CHAP.

CHAP. XVI.

Sailing from the South latitude of 60 degrees 51 min. and from longitude 25 degrees 24 min. 99 leagues, upon a South-weſt courſe: the latitude and longitude of the ſecond place is demanded.

IN the ſecond Demonſtration, draw the Quadrant A B C D E, as is formerly taught; then in regard you ſail South-weſt, take four points of the Compaſs from your Scale, and place them from B unto D, then by the point D draw the line A D F, then place your ninety nine leagues upon the line A D F, from A unto F, ſo ſhall F be the place of your Ship. Then from F draw the line F C parallel unto A E, cutting the line A B C in C, ſo ſhall the diſtance C A be the leagues you have run South, which is 70 leagues, or 3 deg. 30 min. which being added to the latitude from whence you departed, makes 64 deg. and 21 min. for the latitude of the ſecond place: then take the diſtance C F, and apply it unto the line of equal parts, and you ſhall find it likewiſe 70 leagues: Then finding the middle latitude 62 degrees 36 minutes in the Table, Chap. 14. you ſhall find that 9 leagues, and 0 miles, and 61 parts, do alter a degree of longitude in that latitude. Then opening the feet of your Compaſſes to 9 leagues, 0 miles, 61 parts, in the Scale of equal leagues, and keeping the Compaſſes at that diſtance, ſee how many times that diſtance is in the line C F, which is ſeven times and ſomewhat above an half, the true difference of longitude being 7 deg. 36 min. which being ſubſtracted from the longitude from whence you departed, leaves 17 degrees and 48 minutes for the longitude of the ſecond place.

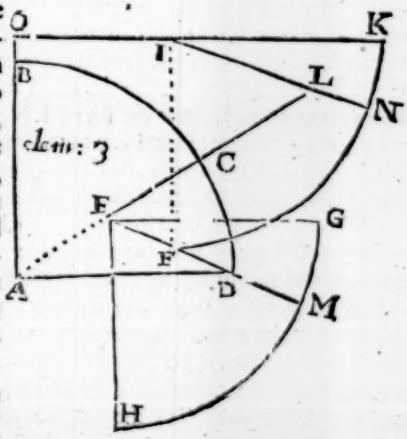


CHAP.

CHAP. XVII.

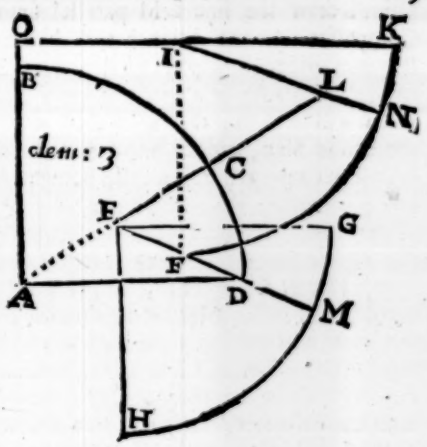
A Ship ſailing from the North Parallel of fifty degrees, having an hundred leagues to ſail South-weſt and by Weſt, by the way is enforced by contrary winds to ſail upon ſeveral points of the Compaſs, firſt ſailing thirty leagues upon a direct courſe, then Weſt North-weſt twenty leagues, then South ſixty leagues; the queſtion is to find the latitude of the ſecond place, how far it is to the place whereunto you are bound, the diſtance of the Rumb that is betwixt them, the diſtance that you are from your firſt Meridian, and thereby the difference of longitude?

IN the third demonſtration draw the line A D, and from the point A, raiſe the perpendicular A B, then open your Compaſs unto the Radius of your Scale, and place one foot thereof in the center A, and with the other draw the Quadrant B C D, then take three points of the Compaſs, and place them upon the Quadrant from D unto C, then from the Center A, by the point C, draw the line A C L 100 leagues in length, which is the true Courſe you are to ſail; Then in regard you ſailed thirty leagues direct, take thirty leagues from your Scale of equal parts, and place them upon the line A E C, it extends from A unto E: then in regard you turned your Courſe Weſt Northweſt, from the Center E, draw the Line E G parallel to A D: and again from the Center E draw the line E H perpendicular to E G, and parallel to A B, then with



with the diſtance of the Radius, ſet one foot of your Compaſſes in the center E, and with the other draw the Quadrant G M H, and in regard you ſailed Weſt Northweſt, which is two points from the Weſt Northward, take from your Scale two points of the Compaſs, and place them upon the Quadrant G M H, from G unto M, then from the center E unto the point M draw the line E F M, then take 20 leagues with your Compaſſes from the Scale of equal parts, and place them upon the line E F M, from E unto F, then is your Ship in the point F. Laſtly, In regard you run South 60 leagues from F, draw a line parallel unto the Meridian A B, which is the line F I, then take from your Scale of equal parts 60 leagues, and place them from F unto I, then is your Ship in the point I: then laſt of all is to be found how far it is to the place whereunto you were bound, the diſtance of the Rumb that is betwixt you, the degrees and minutes you have raiſed the Pole, the diſtance of departure from the firſt Meridian, and thereby the difference of longitude: and that you may ſo do, firſt draw the line O I K perpendicular unto the line I F in the point I, and with your Compaſſes opened unto the diſtance of the Radius, ſet one foot of your Compaſſes in the Center I, and with the other draw the Quadrant K N F, then in regard your Ship is in the point I, and the place whereunto you are bound is the point L, therefore from I thorow the point L draw the line I L N, cutting the arch K N F in the point N, therefore let I L be the leagues you have unto the place whereunto you are bound, which is forty one leagues and a half, and the Rumb the diſtance K N, which is Weſt and by North, and three degrees unto the Northward, ſo likewiſe is the line A O the number of leagues you have run due South, which is ſixty eight leagues and one mile, or three degrees and twenty five minutes, which being taken from fifty degrees, the parallel from which you departed, leaves forty ſix degrees and thirty five minutes for the parallel you are in. Laſt of all ſhall the line I O be the leagues that you have departed your firſt Meridian, which are forty two leagues and one mile; then take the middle latitude, which is forty eight degrees ſeventeen minutes; and in the Table chap. 14. you ſhall find that thirteen leagues, o mile, 92 parts, do anſwer unto a degree of longitude in that parallel; then ſetting one foot of your Compaſſes in

in thirteen leagues, and ninety two parts, extending the other to the beginning of the Scale, keeping the Compaſſes at that diſtance, turn them over the line I O, and you ſhall find it contains that diſtance three times and almoſt a quarter; So the difference of longitude is three degrees eleven minutes.



CHAP. XVIII.

Two Ships departing from one Parallel and Port, the one in ſailing eight leagues betwixt the North and the Weſt, hath raiſed the Pole two degrees; the other in ſailing a hundred leagues betwixt the North and Weſt, hath raiſed the Pole four degrees, I demand by what Rumbs the ſaid Ships have ſailed, and the Rumb and diſtance that is betwixt them?

IN the fourth Demonſtration, draw the Quadrant A B C D E, then in regard the firſt Ship hath raiſed the Pole two degrees, which is forty leagues, take forty leagues off your Scale, and apply them unto the Meridian line A G L, from A unto G: then from the point G, draw the line G F parallel unto A B, then opening your Compaſſes unto 80 leagues, ſet one foot in the Center A, with the other make a mark in the line G F, which will be at F, ſo ſhall F be the place of the firſt ſhip; the ſecond Ship hath raiſed the Pole four degrees, which is 80 leagues, therefore place 80 leagues upon the Meridian line A G L, from A unto L, and from the

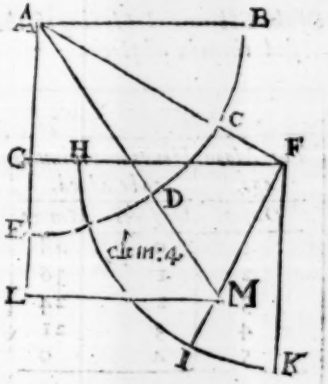
point L draw the line L M parallel unto G H F, then open your Compaſſes unto the diſtance of a hundred leagues, which are the leagues the ſecond Ship did run; and ſet the foot of your Compaſſes in the Center A, and with the other make a mark in the line L M, which will be at M, then draw the line M A, which is the courſe of the ſecond Ship, and the line F A is the courſe of the firſt Ship; then from F let a perpendicular fall, being perpendicular to the line G F, which is the line F K, then opening your Compaſſes unto the Radius of your Scale, ſet one foot in the center F, and with the other draw the Quadrant H I K; likewiſe from F, the place of the firſt ſhip, draw a line by the point M, the place of the ſecond, cutting the Quadrant K I H in I, ſo let I K be the courſe that is betwixt them, that is, if you will ſail from the firſt ſhip unto the ſecond, you muſt ſail North and by Eaſt, and one and forty minutes to the Eaſtward; likewiſe let F M be the diſtance that is betwixt them, which in this Demonſtration is forty Leagues, two miles, ſo ſhall B C be the courſe of the firſt ſhip from the Weſt Northward, which here is found to be thirty degrees and one minute from the Weſt Northward, or North-weſt by Weſt, and three degrees and forty four minutes to the Weſtward. Laſtly, the arch E D is in the diſtance of the courſe that the ſecond ſhip made from the North Weſtward, which is found by this Demonſtration to be Northweſt and by North, and three degrees five minutes to the Weſtward.

CHAP. XIX.

Two Ships departing from one Parallel and Port in the Parallel of 47 *deg.* 56 *min. the firſt in ſailing* 80 *leagues betwixt the North and Weſt, hath raiſed the Pole two degrees, I demand by what courſe the ſecond Ship muſt run, and how much ſhe ſhall alter in her firſt Meridian or Longitude, to bring her ſelf* 40 *leagues and two miles North and by Eaſt, and* 41 *minutes to the Eaſtward of the firſt Ship?*

IN the fourth Demonſtration draw the Quadrant A B C D E, then multiply your two degrees you have altered your latitude by twenty, and make it forty Leagues; which forty Leagues ſet

ſet upon the line A E L, from A unto G; then from the point G draw the line G F parallel unto A B, then open your Compaſſes unto the diſtance of 80 leagues, which are the leagues your firſt ſhip did run, and place one foot of your Compaſſes in the center A, & with the other make a mark in the line G F, which will be at the point F; then from the Center A unto the point F, draw the line A F, repreſenting the diſtance of the Courſe of the firſt Ship 80 leagues: Then from F let fall a perpendicular F K, and upon the Center F, with the Radius of the Scale draw the arch H I K; then in regard you muſt bring the ſecond ſhip North and by Eaſt, and 41 minutes Eaſtward of the firſt ſhip, take 11 degrees 56 minutes from your Scale of Chords, and place them from K unto I, upon the Quadrant K I H. Then from F draw the line I F, and upon the line F I place the diſtance that you muſt bring the ſecond ſhip from the firſt (which is forty leagues and two miles) from F unto M. So is M the place of your ſecond ſhip. Then from M draw the line M L parallel unto F G, cutting the line A G L in L, then draw the line M A, cutting the Quadrant B D E in D. So ſhall the arch D E be the courſe that the ſecond ſhip muſt run, to bring her ſelf 40 leagues and 2 miles North and by Eaſt, and 41 minutes Eaſt of the firſt ſhip. Then to know what you have altered the latitude, firſt take the diſtance L A, and apply it unto the Scale of equal parts, and you ſhall find it to be 80 leagues, which is juſt 4 degrees, which you have altered your latitude or Poles elevation: which 4 degrees added unto the latitude you departed from, it makes 51 deg. 56 min. for the latitude that your ſecond ſhip is in; then take the diſtance L M, and apply it to the Scale, it gives 60 leagues; then open your Compaſſes unto the diſtance of the middle latitude, which is 49 deg. 56 min. of the Chord, and apply it unto the Table of longitudes, and it gives 12 leagues, and 2 miles, and 62 parts, to alter one degree



of longitude in that Parallel; Then ſet one foot of your Compaſſes in 12 leagues 2 miles, and 62 parts, and open the other to the beginning of the line, and with that diſtance meaſure the line L M, being 60 leagues, and you ſhall find that it is contained there in four times and two thirds, ſo the longitude is 4 degrees 40 minutes.

CHAP. XXI.

Of the Ebbing and Flowing of the Sea, and of the Tides, and how to find them in all places.

A general Table for the Tides in all places.

The Moons age.	*Hours and minutes to be added.*		*The Moons age.*	*Hours and minutes to be added.*	
Dayes.	*Degrees*	*Minutes*	*Dayes.*	*Degrees*	*Minutes*
1	0	48	16	0	48
2	1	36	17	1	36
3	2	24	18	2	24
4	3	21	19	3	12
5	4	0	20	4	0
6	4	48	21	4	48
7	5	36	22	5	36
8	6	24	23	6	24
9	7	12	24	7	12
10	8	0	25	8	0
11	8	48	26	8	48
12	9	36	27	9	36
13	10	24	28	10	24
14	11	12	29	11	12
15	0		30	0	0

The uſe of the Table of the Tides.

FIrſt it is to be underſtood, that by the ſwift motion of the firſt Mover, the Moon and all the reſt of the Stars and Planets are turned about the World in four and twenty hours, upon which ſwift motion of the Moon, the daily motions of the Sea do depend; which motion of the Sea falleth not out always at one hour, the reaſon thereof is, becauſe of the ſwift motion of the Moon, in regard ſhe goeth almoſt thirteen degrees in four and twenty hours, and the Sun moveth ſcarce one degree, which gives every day twelve degrees, that the Moon cometh ſlower to any point in the Heaven than the Sun: which twelve degrees, makes forty eight minutes of time for the difference of every full Sea, according unto the middle motion of the Moon, which difference is here ſet down in this Table for every day of the Moons age. Therefore if you would know the full Sea at any place in the World, firſt you muſt know at what hour it is full Sea at the new or full Moon; which hours and minutes keep in mind, then ſeek the age of the Moon, as is before taught, and with the number of her age enter this Table under the Title of the Moons age; and having found her age in the Table, againſt it you ſhall find the hours and minutes which are to be added unto the time that the Moon maketh full Sea in any place, and the whole number of hours and minutes is the time that the Moon maketh full Sea in that place upon the day deſired: as for example, I deſire to know the full Sea at *London* Bridge upon the thirteenth of *July* 1624. the age of the Moon being found as before, is eight days, then in the Table I find eight dayes, and againſt it 6 hours, and 24 minutes, which being added unto three hours, the full Sea upon the Change day gives 9 a clock 24 minutes, for the time at the full Sea upon the 13 day of *July* 1624.

THE

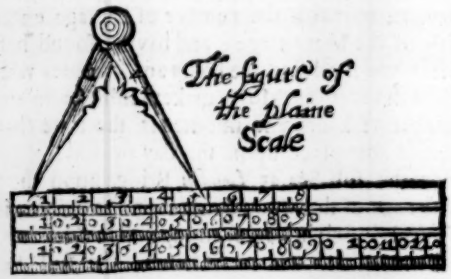
THE SEA-MANS GLASS.

The Second Book.

Wherein is declared the Definition of the Sphere, a Deſcription of the ſix great Circles, and alſo of the four leſſer Circles; laſt of all, certain Queſtions Aſtronomical, performed by the ſaid Scale.

CHAP. I.

Of a Sphere, and the Circles thereof.



A *Sphere*, according to the Deſcription of *Theodoſius*, is a certain ſolid Superficies, in whoſe middle is a Point, from which all lines drawn unto the Circumference are equal; which Point is called the Center of the Sphere; by which Center a right Line being drawn, and extending himſelf on either ſide unto that part of the Circumference whereupon the Spheer is turned, is called *Axis Sphæræ*, or the Axle-tree of the World.

A *Sphere*

A *Sphere* accidentally is divided into two parts, that is to say, *in Speram rectam & Speram obliquam.*

Sphera recta, or a right Sphere, is only unto those that dwell under the *Equinoctial*, *Quibus neuter Polorum magis altero elevatur*: that is, to whom neither of the Poles of the World are seen, but lie hid in the *Horizon.*

Sphera obliqua, or an oblique Sphere, is unto those that inhabit on either side of the *Equinoctial*, unto whom one of the Poles is ever seen, and the other hid under the *Horizon.*

The Circles whereupon the Sphere is composed, are divided into two sorts: that is to say, *in Circulos majores & minores.*

Circuli majores, or the greater Circles, are those that divide the Sphere into two equal parts: and they are in number six, *viz.* the *Equinoctial*, the middle of the *Zodiack*, or the *Ecliptick* line, the two *Colures*, the *Meridian*, and the *Horizon.*

Minores vero Circuli, or the lesser Circles, are such as divide the Sphere into two parts, unequally, and they are four in number; as the Tropick of *Cancer*, the Tropick of *Capricorn*, the Circle *Artick*, and the Circle *Antartick.*

CHAP. II.

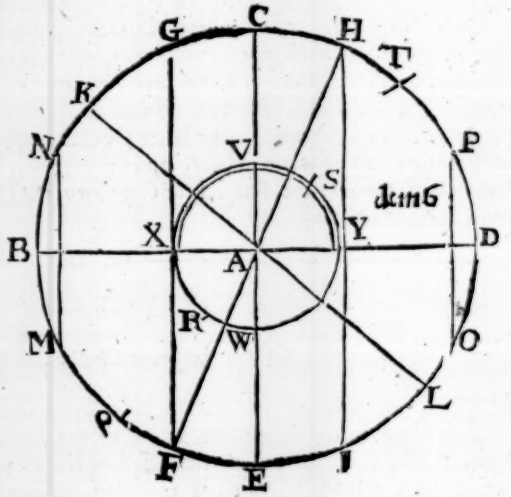
Of the six great Circles.

I. THE *Equinoctial* is a Circle that crosseth the Poles of the World at right Angles, and divideth the Sphear into two equal parts, and is called the *Equinoctial*, because when the Sun cometh unto it, (which is twice in the year, *viz. In principio Arietis, & Libræ*, that is, in *March* and *September*) the Dayes and Nights are equal thoroughout the whole World, whereupon it is called *Equator diei & noctis*, the equal proportioner of the Day and Night artificial: and in the figure is described by the line C A E.

II. The *Meridian* is a great Circle passing thorough the Poles of the World, and the Poles of the *Horizon*, or *Zenith* point over our heads; and is so called, because that in any time of the year, or in any

any place of the World, when the Sun (by the motion of the Heavens) cometh unto that Circle, it is Noon, or 12 of the Clock. And it is to be underſtood, that all Towns and places that lie Eaſt and Weſt one of another, have every one a ſeveral Meridian: but all places that lie North and South one of another, have one and the ſame Meridian. This Circle is declared in the figure following by the Circle B C D E.

III. The *Horizon* is a Circle dividing the ſuperiour *Hemiſphere* from the inferiour, whereupon it is called *Horizon*, that is to ſay, the bounds of ſight, or the fartheſt diſtance that the eye can ſee, and therefore it is alſo called *Circulus hemiſphæri*. The *Horizons* are divided into two ſorts, viz. *Rectus & obliquus*, a right and an oblique, or a declining *Horizon*: whereof thoſe have a right *Horizon* which have the *Equinoctial* for their *Zenith*, & the Poles of the World in their *Horizon*: becauſe the *Horizon* (hiding both the Poles of the World) is a Circle ſuppoſed to be drawn by the Poles of the World, dividing the *Equinoctial* at right angles, as in the Figure following you may plainly ſee. Firſt imagining the Circle X V Y W to be the earth, and thoſe that inhabit at the point V have the line B D for their *Horizon*, cutting the *Equinoctial* C A E at right Angles in A, and therefore is called *Horizon rectus & Sphera recta*, a right *Horizon*, and a right *Sphere*.



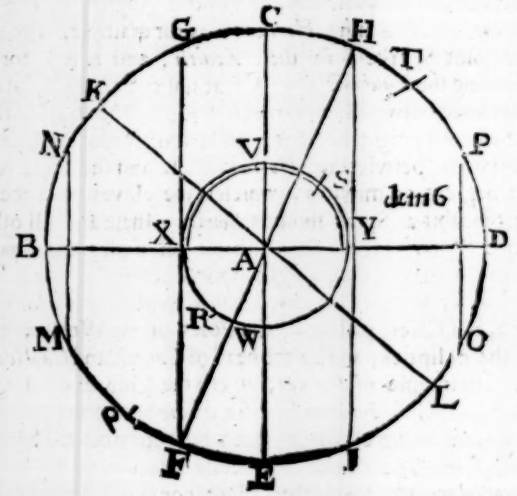
Sphere. Thoſe have an oblique *Sphere*, or an oblique *Horizon*, to whom one of the Poles are viſual, or elevated above the *Horizon*, and have the other hid under the *Horizon*; and in regard ſuch a *Horizon* doth croſs the *Equinoctial*, or oblique Angles, it is called *Horizon obliquus*, or a declining *Horizon*: as for example, Thoſe that inhabit at the point S, have T for their *Zenith*, and K A L for their *Horizon*, dividing the *Equinoctial* C A E at oblique Angles, making the Angle contained betwixt the *Horizon* A K and the *Equinoctial* A C, an angle of thirty eight degrees, and twenty eight minutes, and the angle contained betwixt the *Horizon* A L and the Pole A D, an angle of 51 degrees 32 minutes, which is the elevation of the Pole for thoſe that inhabit at S, as thoſe at *London*; theſe and all other have an oblique *Sphere*, except they inhabit juſt under the *Equinoctial* Circle, unto whom only doth a right *Sphere* belong.

IV. The two Colures, *Colurus Solſtitiorum*, or the Summer Colure, is a Circle paſſing by the Poles of the World, and by the Poles of the Ecliptick, and by the head of *Cancer* and *Capricorn*, whereupon the firſt ſcruple of *Cancer*, where the Colure croſſeth the Ecliptick Line, is called *Punctus ſolſtitiæ æſtivalis*, or the point of the Summer Solſtice: to which place when the Sun cometh, he can approach no nearer unto our *Zenith*, but returneth unto the *Equator* again. *Arcus vero Coluri*, the Ark of the Colure, contained betwixt the Summer Solſtice and the *Equator*, is called the greateſt declination of the Sun, which *Ptolomy* found to be 23 degrees, 31 minutes: *but by the obſervation of* Copernicus *it was found to vary, for he found the declination ſometimes to be* 23 *degrees* 52 *minutes, and in the proceſs of time, to be but* 23 *degrees* 28 *minutes. And in theſe our dayes (by the obſervation of* Tycho de Brache, *and the late famous Mathematician Mr.* Edward Wright) *it is found diſtant from the* Equinoctial 23 *degrees*, 31 *minutes*, 30 *ſeconds.*

V. The other Colure paſſeth by the Poles of the World, and by the firſt point of *Aries* and *Libra*, whereupon it is called *Colurus diſtinguens Æquinoxia.* Theſe two Colures do croſs each other at right angles in the Poles of the World, whereupon theſe verſes were made.

Hæc duo Solſtitia faciunt Cancer Capricornus,
Sed noctes æquant Aries *&* Libra *diebus.*

VI. The Zodiack is another of the greater Circles, dividing the *Equinoctial* into two equal parts by the head of *Aries* and *Libra*, the one half of it doth decline unto the North, and the other into the South, the greateſt of which declinations is 23 degrees, 31 minutes, and 30 ſeconds. Note alſo, this Circle is divided into twelve equal parts, which parts are attributed unto the twelve Signs, *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpio*, *Sagitarius*, *Capricornus*, *Aquarius*, and *Piſces*.



And every one of theſe Signs are divided into 30 equal parts, which are called degrees; ſo the whole Zodiack containeth three hundred and ſixty degrees. Likewiſe every degree is divided into ſixty equal parts, which parts are called minutes, and are in number 21600 minutes; and as 21600 minutes is the whole circumference of the Heavens, ſo is 21600 miles the whole circuit of the Earth.

CHAP.

CHAP. III.

Of the four leſſer Circles.

THe Sun having aſcended unto his higheſt Solſtitial point doth deſcribe a Circle, which is the neareſt that he can approach unto the North Pole, whereupon it is called *Circulus Solſtitii æſtivalis*, the Circle of the Summer Solſtice, or the Tropick of *Cancer*, and is noted in the figure before by the line H Y I.

The Sun alſo approaching unto the firſt ſcruple of *Capricornus*, or the Winter Solſtice, deſcribeth another Circle, which is the utmoſt bounds that the Sun can depart from the Equinoctial Line towards the Antartick Pole, whereupon it is called *Circulus ſolſtitii hyemalis, ſive Tropicus hyemalis, vel Capricorni*, the Circle of the Winter Solſtice, the Winter Tropick, or the Tropick of *Capricorn*, and is deſcribed in the figure by the line G X F.

So much as the Ecliptick declineth from the Equinoctial, ſo much doth the Poles of the Ecliptick decline from the Poles of the World, whereupon the Pole of the Ecliptick, which is by the North Pole of the World, deſcribeth a certain Circle as it paſſeth about the Pole of the World, being juſt ſo far from the Pole, as the Tropick of *Cancer* is from the Equator, and it is the third of the leſſer Circles, and is called *Circulus Arcticus*, or the Circle of the North Pole, and is deſcribed in the *Diagram*, in the ſecond Chapter by the line P O.

The fourth and laſt of the leſſer Circles is deſcribed in like manner by the other Pole of the Ecliptick, about the South Pole of the World, and therefore called *Circulus Antarcticus*, the Antarctick Circle, or the Circle of the Antarctick or South Pole, and is demonſtrated in the former figure, by the line N M.

CHAP. IV.

Definitions of ſome particular terms fit to be known by ſuch as intend to practice the Art of Navigation or Aſtronomy.

THe Zenith is an imaginary point in the Heavens over our heads, making right angles with the Horizon, as the Equinoctial maketh with the Pole.

The *Nadir* is a prick in the Heavens under our feet, making right angles with the Horizon under the Earth, as the Zenith doth above, and therefore is oppoſite unto the Zenith.

The declination of the Sun is the Ark of a Circle contained betwixt the place of the Sun in the Ecliptick and the Equinoctial, making right angles with the Equinoctial. But the declination of a Star is the Ark of a Circle let fall from the Center of a Star, perpendicularly unto the Equinoctial.

The Latitude is the ark of a Circle contained betwixt the Center of any Star and the Ecliptick Line, making right angles with the Ecliptick, and counted either Northward or Southward, according to the ſcituation of the Star, whether it be nearer unto the North or South Pole of the Ecliptick.

The Latitude of a Town or Country is the height of the Pole above the Horizon, or the diſtance betwixt the Zenith and the Equinoctial.

The Longitude of a Star, is that part of the Ecliptick which is contained betwixt the Stars place in the Ecliptick, and the beginning of *Aries*, counting them from *Aries*, according to the ſucceſſion or order of the Signs.

The Longitude of a Town or Countrey are the number of degrees which are contained in the Equinoctial, betwixt the Meridian that paſſeth over the Iſles of *Azores*, (from whence the beginning of longitude is accounted) Eaſtwards, and the Meridian that paſſeth over the Town or Country deſired.

The Altitude of the Sun or Star is the arch of a Circle contained betwixt the Center of the Sun, or any Star, and the Horizon.

The

The Amplitude is that part of the Horizon which is betwixt the true Eaſt or Weſt points, and the point of the Compaſs that the Sun or any Star doth riſe or ſet upon.

Azimuth's are Circles which meet together in the Zenith, and croſs the Horizon at right angles, and ſerve to find the point of the Compaſs which the Sun is upon at any hour of the day; or the Azimuth of the Sun or Star, is a part of the Horizon contained betwixt the true Eaſt or Weſt point, and that Azimuth which paſſeth by the Center of the ſame Star to the Horizon.

The right aſcenſion of a Star is that part of the Equinoctial that riſeth or ſetteth with the Star in a right Sphere: or in an oblique Sphere, it is that proportion of the Equinoctial, contained betwixt the beginning of *Aries*, and that place of the Equinoctial which paſſeth by the Meridian with the Center of the Star.

The oblique aſcenſion is a part of the Equinoctial, contained betwixt the beginning of *Aries*, and that part of the Equinoctial that riſeth with the Center of a Star in an oblique Sphere.

The difference aſcenſional, is the difference betwixt the right and oblique aſcenſion: or it is the number of degrees contained betwixt that place of the Equinoctial that riſeth with the Center of a Star, and that place of the Equinoctial that cometh unto the Meridian, with the Center of the ſame Star.

Almicanterahs are Circles drawn parallel unto the Horizon, one over another, until you come unto the Zenith: theſe are Circles that do meaſure the elevation of the Pole, or height of the Sun, Moon, or Stars above the Horizon, which is called the Almicanter of the Sun, Moon, or Star: the Ark of the Sun or Stars Almicanter, is a portion of an Azimuth contained betwixt that Almicanter which paſſeth thorow the Center of the Star and the Horizon.

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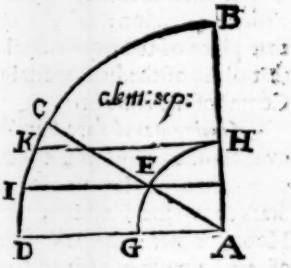
QUESTIONS ASTRONOMICAL, performed by the plain Scale.

CHAP. V.

The true place of the Sun being given, to find his declination.
The Sun being in the head of Taurus, *his declination is deſired.*

BY the ſeventh Demonſtration draw the line A D, then upon the Center A raiſe the perpendicular A B, then opening your Compaſſes to the Radius of your Scale, place one foot in the Center A, and with the other draw the Quadrant B C D, then opening your Compaſſes unto the greateſt declination of the Sun, place it upon the Quadrant from D unto K, then from the point K draw the line K H parallel to D A, cutting the line A B in H, then with the diſtance A H draw the ſmall Quadrant G E H, and in regard the Sun is in the head of *Taurus*, which is 30 degrees from the beginning of *Aries*, let A D be the Equator, and D the beginning of *Aries*, D C 30 degrees, or longitude of the Sun, then from the point C draw the line C A, cutting the Quadrant G E H in E, then from E draw the line E I parallel to A D, cutting the Quadrant B C D in I, ſo ſhall the arch I D be the declination of the Sun deſired, which in this Demonſtration is found to be eleven degrees, and thirty one minutes.



CHAP. VI.

The declination of the Sun, and quarter of the Ecliptick that he poſſeſſeth, being given, it is deſired to find his true place.

The Declination is 10 *deg.* 31 *min. the firſt quarter that he poſſeſſeth, is betwixt the head of* Aries *and Cancer.*

FIrſt, by the ſeventh Demonſtration, draw the Quadrant A B C D, as is taught in the former Chapter, then ſet the greateſt declination of the Sun upon the Chord from D unto K, which is 23 deg. and 31 min. then from K draw the line K H parallel unto the *Equator* D A, cutting the line B A in the point H. So ſhall H A be the ſign of the Suns greateſt declination; then with the diſtance A H draw the Quadrant G E H, then from D upon the Quadrant D B C ſet the Declination of the Sun, which is 11 degrees, 31 minutes from D unto I, then draw the line I E parallel unto A D, cutting the Quadrant G E H in E. Then from the center A by the point E, draw the line A E C, cutting the Quadrant B C D in C. So ſhall the Ark C D be the diſtance of the Sun from the head of *Aries*, which is here found to be juſt 30 degrees, which is in the beginning of *Taurus.*

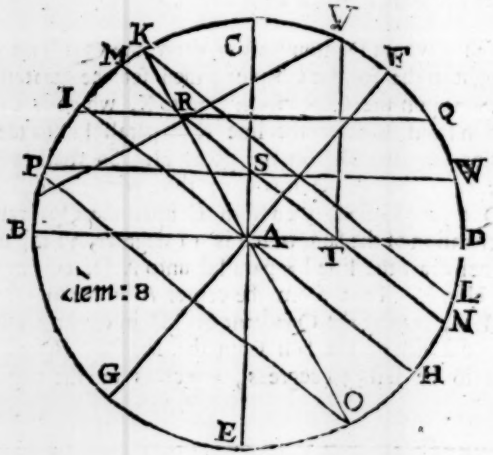
CHAP. VII.

By the elevation of the Pole, and declination of the Sun, to find the amplitude of the Sun, or his diſtance of riſing or ſetting from the true Eaſt or Weſt point.

The elevation of the Pole is 51 *deg.* 32 *min. the declination of the Sun is* 14 *deg.* 52 *min. North.*

BY the eight Demonſtration, firſt draw the line B D, then upon the Center A draw the Circle B C D E, then from A raiſe the perpendicular C A E, then is your Circle divided into four equal parts: then ſuppoſe the elevation of the Pole to be

be 51 degrees, 32 minutes, which must be placed upon the Circle, from D unto F, then from the point F by the Center A draw the line F A G, representing the Pole of the World, F being the North Pole, and G the South Pole; then substract 51 deg. 32 min. from 90 deg. and the remainer is the height of the Equinoctial, which is 38 deg. 28 min. which must be placed upon the Circle from the Horizon B unto



the point I, then from I, by the Center A draw the line I A H, representing the Equinoctial Circle. Then from I unto M set the declination of the Sun, being here supposed 14 deg. 52 minutes North, then from the point M draw the line, or Parallel of Declination M T N, parallel unto the Equator I A H, cutting the Horizon B D in T, then from T raise the perpendicular T V, cutting the Circle B C D E in V, so shall the distance C V be the true amplitude of the Sun desired, which here is found to be 24 deg. 21 minutes North.

CHAP.

CHAP. VIII.

By the Amplitude of the Sun, to find the variation of the Compaſs.

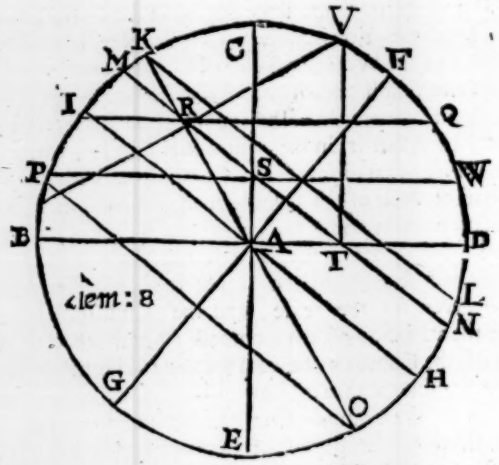
HAving found the amplitude of the Sun by the laſt Chapter, firſt obſerve with a Compaſs, or rather with a Semicircle, upon what degree and minute the Sun riſeth or ſetteth, beginning to reckon from the Eaſt or Weſt, and ending at the North or South at 90 degrees: and when you have diligently obſerved the Magnetical riſing or ſetting by the Semicircle, or by ſome other like fitting Inſtrument: and alſo the true amplitude found, as is declared in the laſt Chapter, the difference of theſe two amplitudes, is the variation of the Compaſs: But when the Sun riſeth upon the ſame degree of the Compaſs as is found by the Scale, the variation is nothing, but the Needle pointeth directly unto the Poles of the World, which by M. *Moulineux* was affirmed to be at the Weſternmoſt part of St. *Michaels*, one of the Iſlands of the *Azores*, from whence he will have the Longitude reckoned. Secondly, when the Sun is in the Equinoctial Circle, where he hath no amplitude, look what diſtance the Compaſs maketh the Sun to riſe from the Eaſt or Weſt of the Compaſs, the ſame diſtance is the Compaſſes variation from the North or South. Thirdly, If the Sun riſe more to the South of the Compaſs, or ſetteth more to the North of the Compaſs than is ſhewed by the Scale, the difference betwixt the Amplitude given by the Scale, and the Amplitude given by the Needle, is the variation of the Compaſs from the North Weſtward. Fourthly, If the Compaſs ſheweth the Sun to riſe more Northward, or ſet more Southward than is ſhewed by the Scale, the difference is the variation of the Compaſs from the North Eaſtward. Fifthly, If the Scale ſhew the amplitude of the Sun riſing Southerly, and the Compaſs ſhew it to be Northerly, add both the amplitudes together, and they ſhew you the variation Weſternly.

CHAP. IX.

The place of the Sun being given, to find his declination, by a whole Circle.

The Suns place is the tenth degree of Taurus.

ACcording unto the eighth Demonſtration, firſt draw the Circle B C D E, then draw the Horizon B A D, and then the Equinoctial I A H, as is before taught: and then the Tropick of *Cancer* K L twenty three degrees and a half from the Equinoctial: then draw the Tropick of *Capricorn* P O, of like diſtance from the Equinoctial,



and after from K to O draw the Ecliptick line K A O. And when you have thus laid down the Sphere, ſuppoſe the Sun to be in the tenth degree of *Taurus*, at which time his declination is deſired. And in regard the Sun is more near unto the Tropical point *Cancer* than unto *Capricorn*, firſt find how many degrees he is from the Tropick of *Cancer*,

ter, and you ſhall find him to be 50 degrees; therefore take with your Compaſſes 50 degrees from the Chord, and apply it from the Tropical point *Cancer* at K unto V upon one ſide, and unto P on the other ſide: then draw the line V P, cutting the Ecliptick K O, in the point R, then from R draw the line M R N parallel unto the Equinoctial I A H, and cutting the Quadrant B C in the point M. So ſhall the ark M I be the declination of the Sun deſired, which being applied unto your Scale, gives 14 deg. and 52 min.

CHAP. X.

The elevation of the Pole, and declination of the Sun given, to find his height in the vertical Circle.

The Pole is elevated 51 degrees 32 minutes, the declination of the Sun is 14 degrees 52 minutes North, his height in the Vertical Circle is found as followeth.

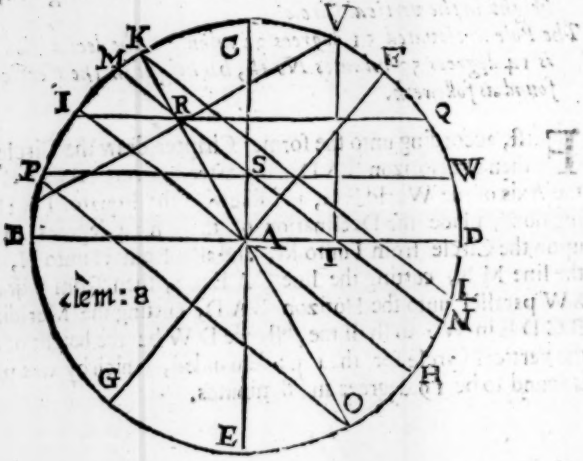
FIrſt, according unto the former Chapter, draw the Circle B C D F, then the Horizon B A D, and after the vertical line C A E, then the Axis of the World F G, and likewiſe the Equator I A H, this being done, place the Declination of the Sun 14 degrees 52 minutes, upon the Circle from I unto M, and alſo from H unto N, then draw the line M N, cutting the line C A E in S, then from S draw the line S W parallel unto the Horizon B A D, cutting the Meridian Circle B C D E in W: ſo ſhall the diſtance D W be the height of the Sun in the vertical Circle for the time demanded, which by this propoſition is found to be 19 degrees and 8 minutes.

CHAP. XI.

The elevation of the Pole, and the Amplitude of the Sun being given, to find the declination.

The elevation of the Pole is 51 degrees 32 minutes, the Suns amplitude is 24 degrees 21 minutes, the declination is found as followeth.

First, As in the eight demonſtration, upon the Center A, draw the Circle B C D E, then draw the Line B A D, repreſenting the Horizon: dividing the circle into two equal parts



then draw the Line C A E, perpendicular to B A D, repreſenting the Eaſt and Weſt points of the Compaſs, then placing the elevation of the Pole 51 degrees and 32 minutes, from D unto F, from F by the center A draw the line F A G, which let be the Pole or Axle-tree of the World; then from B unto I, and from D unto H, ſet

set the Complement of the Poles elevation; which shall represent the Equinoctial, in regard it maketh right angles with the Pole of the World in the center A. Then from C unto V place the amplitude of the Sun, which is 24 degrees and 21 minutes: then from V let fall the perpendicular V T, cutting the Horizon B A D in the point T, then from the point T draw the line M T N parallel unto the Equinoctial I A H, and cutting the Circle B C D E in the points M and N, so shall the distance I M or H N be the declination of the Sun, which was desired: which being applied unto your Scale, gives you fourteen degrees and fifty two minutes.

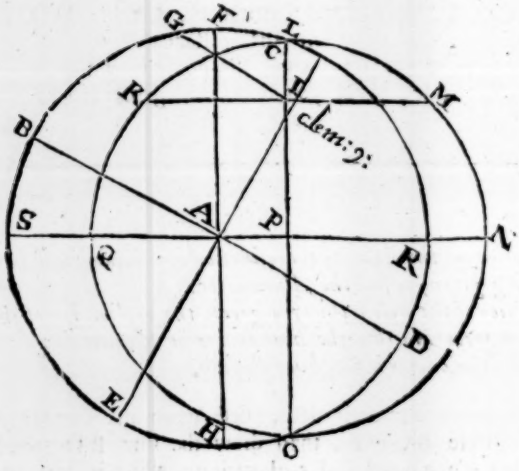
CHAP. XII.

The elevation of the Pole, the declination of the Sun, and hour of the day being given, to find the Almicanter.

The elevation of the Pole is thirty degrees, the declination of the Sun is twenty degrees North, the hour is nine in the morning, at which time the Almicanter is found as followeth.

BY the ninth demonstration, first upon the Center A draw the Circle B C D E, then draw the line B D for the Horizon, then place your Poles elevation, which is thirty degrees, upon the Circle from D unto R, then from R by the center A draw the line R A S, representing the Axis of the World, then from B unto F place the complement of the Poles elevation, which is 60 degrees, and from the point F, by the Center A, draw the line F A H, representing the Equinoctial line, and then set the declination of the Sun from F unto L, and from L draw the line L P O parallel unto the Equator F A H, cutting the Axis of the World in the point P, then set one foot of your Compasses in the point P, and extend the other either unto L or unto O, and with the same distance of your Compasses, upon the center P draw the circle L N O Q, which is called the hour circle: so shall L be the point of twelve a clock at noon, N the place of six a clock afternoon, O the place of twelve a clock or midnight, and Q the place of six a clock in

in the morning: Every one of the four quarters muſt be divided into ſix equal parts or hours, making the whole Circle to contain twenty four parts, repreſenting the 24 hours of the day and night, then in regard the hour of the day was nine of the clock, which is three hours before noon, take three of thoſe twenty four hours, and place them



upon the Circle L N O Q from the Meridian point L unto K, the nine a Clock point in the morning, and unto M the point of three of the clock afternoon, then draw the line M K, cutting the parallel of the Sun L O in the point I, then from I draw the line I G parallel unto the Horizon B A D, which ſhall cut the Meridian Circle B C D E in the point G, ſo ſhall the diſtance of G and B, be the Almicanter the Sun, which was deſired; which in this demonſtration is found to be forty eight degrees and eighteen minutes.

CHAP.

CHAP. XIII.

The elevation of the Pole, the Almicanter, and declination of the Sun being given, to find the hour of the day.

The elevation of the Pole is thirty degrees, the declination of the Sun is twenty degrees, the Almicanter of the Sun is forty eight degrees, and eighteen minutes, the hour of the day is found as followeth.

FIrſt, as in the ninth demonſtration, upon the Center A draw the Circle B C D E, then draw the Diameter B D, repreſenting the Horizon, then from D unto R ſet 30 degrees, the elevation of the Pole, then from R unto the point A draw the line R A S, repreſenting the Pole of the World, then draw the line F A H, croſſing the Pole in A, at right Angles cutting the Meridian circle in F, then from F ſet twenty degrees, the declination of the Sun unto L, and then from the point L, draw the line L P O, repreſenting the parallel of the Sun, and cutting the Pole of the World in P, then placing one foot of your Compaſſes in P, extend the other unto L, with which diſtance of your Compaſſes draw the hour Circle L N O Q, then from the Horizon at B, place the Suns Almicanter: (which is forty eight degrees, and eighteen minutes) upon the Quadrant B G L, from B unto G, then from the point G draw the line G I parallel unto the Horizon B A D, cutting the line L O in I, then from the point I draw the line K I M parallel to the Pole of the World Q A N, cutting the Circle L N O in M, then let L N be divided into ſix hours, whereof L M are three: whereupon I conclude, that it is three hours from noon, that is, at nine of the clock in the morning, or three in the afternoon.

CHAP.

CHAP. XIV.

The Latitude of the place, the Declination of the Sun, and the Altitude of the Sun being given, to find the hour of the day: By a new way differing from that in the former Chapter.

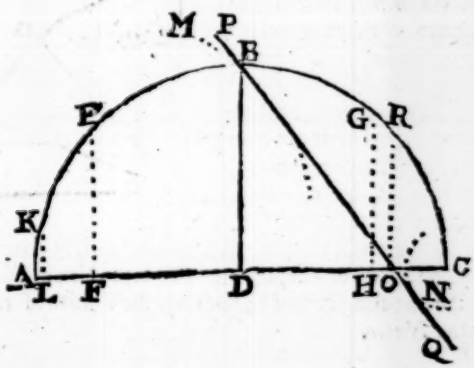
	deg.	min.		deg.	m.
The Suns Alitude is	48	18			
The Latitude of the place is	30	00	its Compl. N.	60	00
The Suns declination is	20	00		70	00
			Sum	130	00
			difference	10	00

The Complement of any arch less then 90 degrees, is so much as the arch wants of 90 degrees, as the Complement of 20 degrees is 70 degrees, &c.

First find the sum and difference of the Complement of the Suns declination, and the Complement of the Latitude, as above is done, where the sum is 130 degrees, and the difference 10 degrees. Then your Compasses being opened to the Radius of your line of Chords, describe the Semicircle A B C, and divide it into two Quadrants by the perpendicular B D, then out of your line of Chords take 48 deg. 18 min. the Suns Altitude, and set it from B to E, and draw E F parallel to B D: Then from your line of Chords take 130 deg. the sum, and set it from A to G, (or its Complement to 180 deg. which is 50 deg. from C to G) and draw the line G H also parallel to B D. Again, out of your line of Chords take 10 deg. (which is the difference) and set that distance from A to K, and draw K L parallel to E F or B D.

This done, take with your Compasses the distance from F to H, and setting one foot in A, with the other describe the arch M P, likewise take the distance from F to L, and setting one foot in C, with

with the other deſcribe the arch N Q. Laſtly, Draw the ſtraight line P Q, which only touching the two former arks will cut the line A C in O, upon the point O therefore erect the perpendicular O R, cut-



ting the Semicirele in R, ſo will C R being meaſured upon your line of Chords, give you the degrees of the Sun from the South part of the Meridian, which here you will find to be 45 degrees, which makes 3 hours, allowing 15 degrees for an hour, for 15 degrees make one hour, and one degree makes 4 minutes of an hour, ſo that it is either 9 of the clock in the morning, or 3 in the afternoon.

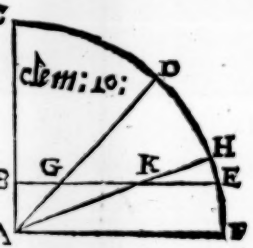
CHAP. XV.

The Almicanter, or height of the Sun being given, to find the length of the right ſhadow.

The Almicanter is 45 degrees.

ACcording unto the tenth Diagram, draw the line A F, and upon the center A raiſe the perpendicular A C, then upon the center A draw the Quadrant C D F, then ſuppoſe the

height of your *Gnomon*, or ſubſtance yielding ſhadow be the line A B, which is to be divided into 12 equal parts, which *Gnomon* I have here made juſt 12 degrees of the equal leagues of the Scale, then from B to the top of the *Gnomon* draw the line B E parallel unto A F, then ſet the Almicanter which is forty five degrees from F unto D, and from the point D draw the line D A, cuttin. the line B E in the point G, ſo ſhall B G be the length of the right ſhadow deſired, which here is found to be 12 parts, which is but juſt the length of your *Gnomon*, $\frac{2}{12}$ and $\frac{1}{3}$ of a twelfth over: Note that the right ſhadow is the ſhadow of any poſt, ſtaff, or ſteeple, that ſtandeth at right angles with the Horizon, the one end thereof reſpecting the Zenith of the place, and the other the *Nadir*.



CHAP. XVI.

The Almicanter, or height of the Sun being given, to find the length of the contrary ſhadow.
The Almicanter given is 70 *degrees.*

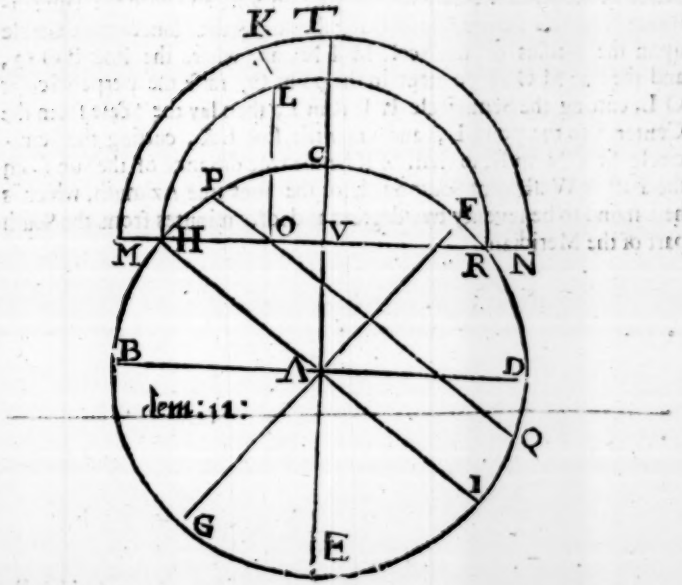
BY the verſe or contrary ſhadow, is underſtood the length of any ſhadow that is made by a ſtaff or *Gnomon* ſtanding againſt any perpendicular Wall, in ſuch a manner that it may lie parallel unto the Horizon, the length of the contrary ſhadow doth increaſe as the Sun riſeth in height; whereas contrariwiſe, the right ſhadow doth increaſe in length, as the Sun doth decreaſe in height: the way to find the verſe ſhadow is as followeth. Firſt, draw your Quadrant as is taught in the laſt Chapter, wherein let A B be the length of the *Gnomon*; likewiſe from B, draw the line B E parallel unto A F, as before, then ſet your Almicanter from C upon the Quadrant which is given to be ſeventy degrees and it will extend from C unto H, then from the point H draw the line H A, cutting the line B E in the point K, ſo ſhall K B be the length

length of the contrary shadow, which here is found to be thirty four degrees and eight minutes, or twice so long as your *Gnomon*, and $\frac{10}{25}$ about $\frac{1}{3}$ part of a twelfth more.

CHAP. XVII.

The latitude of the place, the Almicanter, and declination of the Sun being given, to find the Azimuth.

The latitude of the place is fifty one degrees, thirty minutes, the declination of the Sun twenty degrees North, the Almicanter thirty eight degrees thirty minutes, the true Azimuth of the Sun is desired.



First, as in the eleventh Demonstration upon the Center A, draw the Circle B C D E, then draw the Diameter B A D, and from D unto F, set the Elevation of the Pole, which is

one and fifty degrees, and thirty minutes, whoſe complement is eight and thirty degrees and thirty minutes, which muſt be placed from B unto H, then from H draw the line H A I, repreſenting the Equinoctial line, and from F draw the line F A G, repreſenting the Pole of the World, then from H unto P, and from I unto Q, ſet the Declination of the Sun, which is twenty degrees, and by theſe two points draw the line P Q, for the parallel of the Suns declination; then upon the Circle from B unto H ſet the Suns Almicanter, thirty eight degrees, and thirty minutes; then from H draw the line H R parallel unto the Horizon cutting the Suns parallel P O Q in O, then draw the line T V A E perpendicular unto the line B A D in the Center A, and cutting the line H V R in V, then ſetting one foot of your Compaſſes in the point V, extend the other unto R, and with the ſame diſtance draw the Semicircle H L R, then draw the Concentrick Circle upon the Radius of the Scale M T N, and where the line P O Q, and the line M O N do meet in the point O, raiſe the perpendicular O L, cutting the Semicircle H L R in L, then lay the Scale from the Center A to the point L, and draw the line L K, cutting the Semicircle M T N in K, ſo ſhall M K be the true diſtance of the Sun from the Eaſt or Weſt point Southward, or the Suns true Azimuth, which is here found to be ſeventy two degrees and forty minutes from the South part of the Meridian.

CHAP.

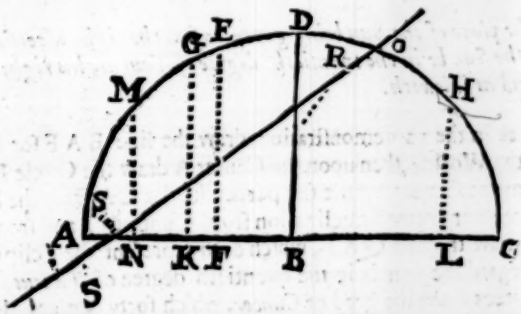
CHAP. XVIII.

The Latitude of the place, the Declination of the Sun, and the Altitude of the Sun being given, to find the Azimuth: By a new way differing from that in the former Chapter.

	deg.	min.	S.		deg.	m.
The Suns declination is	20	00	} its Compl.		38	30
The Latitude of the place is	51	30				
The Suns Altitude is	12	00			78	00
				Sum	116	
				difference	39	30

HAving found the sum and the difference of the Complement of the Suns altitude and Complement of the latitude as above is expressed, where you find the sum of them to be 116 deg. 30 min. and their difference 39 deg. 30 min.

These things being premised, with your Compasses being opened to 60 deg. of your line of Chords, describe the Semicircle A D C, and



upon the Center B erect the perpendicular B D, then first out of your line of Chords take 20 deg. the Suns declination, and set that distance

diſtance from D to E, (if the Sun have South declination (as in this Example it hath) or from D to O, if the Sun have North declination) and draw the line E F parallel to D B.

Secondly, Take 116 deg. 30 min. the ſum out of your line of Chords, and ſet it from C to G, and draw the line G K parallel to D B.

Thirdly, Take 39 deg. 30 min. the difference, out of your line of Chords, and ſet it from C to H, and draw the line H L parallel alſo to B D.

Fourthly, Take in your Compaſſes the diſtance from F to K, and ſetting one foot in A, with the other deſcribe the arch S.

Fifthly, Take the diſtance from F to L, and ſetting one foot in C, with the other deſcribe the arch R.

Sixthly, Lay a Ruler that it may only touch theſe two arches, S and R, and by it draw a line as S R, cutting the line A C in N.

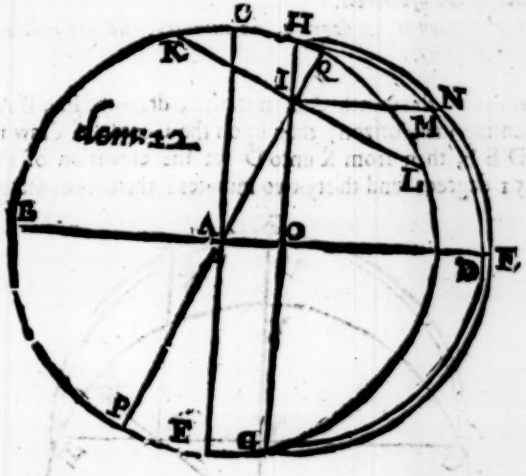
Laſtly, Upon the point N, erect the perpendicular N M, then the diſtance A M meaſured upon your line of Chords, is the Azimuth from the South part of the Meridian, which in this example will be found to be 34 deg. M C the Azimuth from the North 146 deg. and M D the Azimuth from the Eaſt or Weſt 56 deg.

CHAP. XIX.

The place of the Sun being given, to find the right aſcenſion. Suppoſe the Sun be in the twentieth degree of Taurus, his right aſcenſion is found as followeth.

FIrſt, as in the 12 demonſtration, draw the line B A F for the Pole of the World; then upon the Center A draw the Circle B C D E, then from the Center A raiſe the perpendicular C A E for the Equator, then place your greateſt declination from C unto Q, and from E unto P, then draw the line Q A P, which doth repreſent the Ecliptick line, then in regard the Sun is in the twentieth degree of *Taurus*, which is forty degrees from the head of *Cancer*, which forty degrees place from Q unto L and unto K, then draw the line K L, cutting the Ecliptick in I; then from the point I draw the line H I parallel unto C A E, cutting the Pole of the World in O, then ſet one foot of your Compaſſes in

in O, and extend the other unto G, with which diſtance draw the Semicircle H D G, then opening your Compaſſes unto the Radius of the Scale, and upon the Center O likewiſe draw the Circle H N F G, then



draw the line I M parallel unto A O D, cutting the Semicircle H M D G in M, then lay your Scale from the center O unto the point M, and draw the line N M, cutting the Concentrick Circle in N, ſo ſhall the diſtance N F be the right aſcenſion, which is here found to be two and forty degrees, ſeven and twenty minutes.

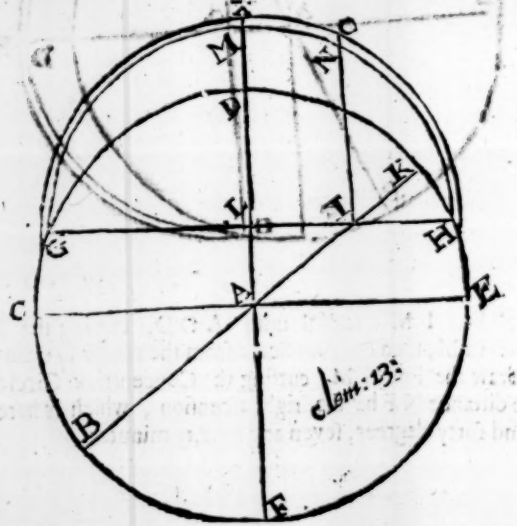
CHAP.

CHAP. XX.

The elevation of the Pole, and declination of the Sun given, to find the difference of the aſcenſions.

The Poles elevation is 51 degrees, 32 minutes, the declination of the Sun is 21 degrees.

FIrſt, as in the thirteenth demonſtration, draw the line B A K, repreſenting the Horizon, then upon the Center A draw the Circle B C D E F, then from K unto D ſet the elevation of the Pole which is 51 degrees and thirty two minutes: then from the point D,



by the Center A, draw the line D A F, repreſenting the Pole of the World, then from B unto C ſet the Complement of the Poles elevation which is thirty eight degrees, and 28 minutes: then from C by the Center A draw the line C A E, repreſenting the Equinoctial line; then

then from C unto G, and likewiſe from E unto H, for the declination of the Sun, which is 21 degrees, then from G unto H draw the parallel of the Suns declination, cutting the Pole of the World in L, and the Horizon in I, then ſet one foot of your Compaſſes in the point L, and extend the other unto G, then with that diſtance of your Compaſſes draw the Semicircle G M N H, then opening your Compaſſes unto the Radius of your Scale, upon the ſame Center draw the Concentrick Circle G X O H, then from I, where the declination of the Sun doth cut the Horizon, draw the Line I N parallel unto the Pole of the World A M, cutting the circle G M H in N, then lay your Ruler from the point I unto the point N, and ſo draw the line N O, cutting the Concentrick Circle G X O H in O, ſo ſhall the diſtance of O and X, be the difference of the aſcenſions, which is here found to be eight and twenty degrees, and four and fifty minutes.

CHAP. XXI.

The right aſcenſion of the Sun or of a Star being given, together with the difference of their aſcenſion, to find the oblique aſcenſion or deſcenſion.

The Sun is in the fourth degree of Sagitarius, *his right aſcenſion is* 242 *degrees, or* 16 *hours* 8 *minutes, the difference of aſcenſion is* 1 *hour* 53 *minutes, or* 28 *degrees,* 28 *minutes, the oblique aſcenſion or deſcenſion is required.*

THe right aſcenſion of any point of the Heavens being known, the difference of the aſcenſion is either to be added thereunto, or elſe to be ſubſtracted from it, according as the Star is ſituate in the Northern or Southern Signs: As for example, if the Sun be in any of theſe ſix Signs, *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *or Virgo*, then the difference of the aſcenſions is to be ſubſtracted from the right aſcenſion, and the remainer is the oblique aſcenſion. Suppoſe therefore the Sun to be in the fourth degree of *Gemini*, where the right aſcenſion is found to be four hours, and 8 minutes, or 62 degrees, and the difference of aſcenſion where the Pole is elevated 51 degrees, is found to be one hour 53 minutes, otherwiſe 28 degrees 50

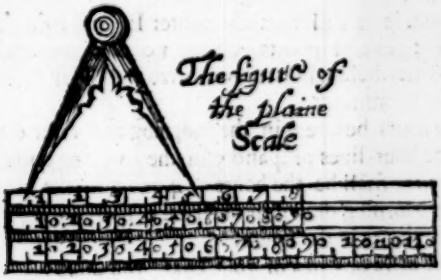
minutes, which being taken from the right aſcenſion, leaves two hours and 16 minutes, or 33 degrees and 42 minutes, which is the oblique aſcenſion of the Sun in the fourth degree of *Gemini*. But if the Sun be upon the South ſide of the Equinoctial, either in *Libra*, *Scorpio*, *Sagitarius*, *Capricornus*, *Aquarius*, or *Piſces*, then the difference of the aſcenſions is to be added unto the right aſcenſion, and the Product will be the oblique aſcenſion. Suppoſe the fourth degree of *Sagitarius* is given, for which ſign and degree the oblique aſcenſion of the Sun is deſired, his right aſcenſion being then found to be 242 degrees, or 16 hours 8 min. the difference of the aſcenſions is one hour 53 min. or 28 degrees 18 minutes: which being added unto the right aſcenſion, makes 18 hours one minute; or in degrees 270 degrees and 18 minutes, which is the oblique aſcenſion of the Sun when he is in the fourth degree of *Sagitarius*. And if you would find the oblique deſcenſion, you muſt add the difference of the aſcenſions unto the right aſcenſion, when the Sun is in theſe ſix Signs, *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*: and contrariwiſe, when the Sun is in the other ſix Signs, you muſt ſubſtract the difference from the right aſcenſion, and you ſhall have the oblique deſcenſion of the Sun or any Star, whoſe right aſcenſion and difference of aſcenſions is known. But it is to be underſtood, that this manner of operation doth ſerve no longer than you are upon the North ſide of the Equinoctial. For if the South Pole be elevated, the work is contrary: for ſo long as the Sun is in any of the Northern Signs, the difference of the aſcenſions is to be added unto the right aſcenſion, to find the oblique aſcenſion; and contrariwiſe, ſubſtracted to find the oblique deſcenſion. Likewiſe if the Sun or Star be in the Southern Signs, then is the difference of aſcenſions ſubſtracted from the right aſcenſion to find the oblique aſcenſion, and added to find the oblique deſcenſion.

The End of the Second Book.

THE SEA-MANS GLASS.

The Third Book.

Shewing how by the Plain Scale to delineate Hour-lines upon all kind of Upright Plains, either Direct or Declining, in any Latitude.



CHAP. I.

How to draw Hour-lines upon an Horizontal Plain in any Latitude.

With the Radius of your line of Chords, upon E as a Center, describe the Circle A B C D, and cross it with the Diameters A B and C D. This done, out of the line of Chords take the Complement of the Latitude of your place (which we here suppose to be *London*, whose Latitude is 51 deg.

30 min. and its complement 38 deg. 30 min.) which ſet from B to G, from G to N, and from D to M; then lay a Ruler from A to G, and it will cut the line C D in H, and from A to N it will cut C D in O, and from A to M it will cut the ſame line in F.

This done, upon O (as a center) place one foot of your Compaſſes, and extend the other foot to F, and with this diſtance deſcribe an arch of a circle, which (if the reſt of your work be true) will fall juſt in the points A and B, and ſo conſtitute the arch A F B repreſenting the Equinoctial Circle, and ſo we ſhall hereafter call it.

Having drawn the Equinoctial A F B, divide the Semicircle A D B into 12 equal parts in the points * * * &c. Then laying a Ruler to the center E, and every one of theſe marks * * * &c. it will divide the Equinoctial circle into 12 unequal parts in the points ●●●● &c.

Again, Lay a Ruler to H, and every of theſe unequal parts ●●●● &c. it will cut the ſemicircle A D B in the points 7, 8, 9, 10, 11, 12, 1, 2, 3 4, 5 and 6.

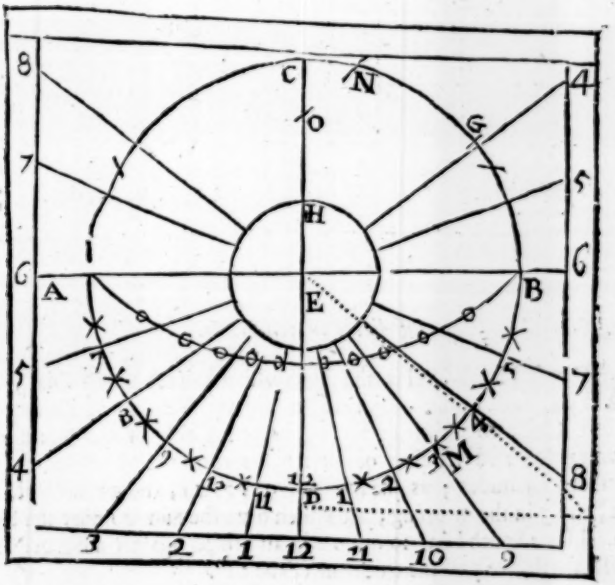
Laſtly, If you lay a Ruler on the center E, and from thence draw right lines to the ſeveral points 7, 8, 9, 10, &c. they ſhall be 12 of the true hour-lines belonging to an Horizontal Dial for the latitude of 51 degrees, 30 minutes.

But for the hours before 6 in the morning and after 6 at night, do thus; draw the hour-lines of 4 and 5 in the Evening quite through the center E, and they ſhall be the hours of 4 and 5 in the Morning; alſo 7 and 8 in the Morning drawn through the center, ſhall give the hours of 7 and 8 at night, as in the figure.

Now for the Stile or Cock of your Dial, you muſt take out of your line of Chords the degrees of your Latitude, *viz.* 51 degrees, 30 minutes, and ſet it from D to S, and draw the line D S, ſo ſhall the triangle D E S be the juſt pattern for the Cock of your Dial, which being made of Braſs, or the like, and ſet exactly upright upon the hour-line of 12, your Dial is wholly finiſhed.

An

An Horizontal Dial for the Latitud of 51 deg. 30 minutes.

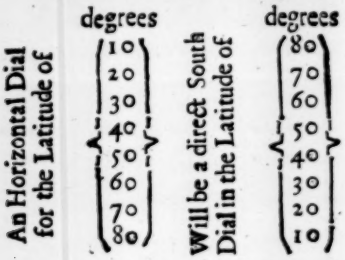


CHAP. II.

Concerning direct South Dials.

A Direct South Dial is no other then an Horizontal Dial, the making whereof is before deſcribed, the difference conſiſting only in the numbring of the hours; and in the placing of it, the one being to be fixed on a Poſt, or the like, and the other to be fixed to a Wall which exactly beholds the South, I ſay here is no other difference: For,

An



And the like in any other Latitude, as 15, 16, 33, &c.

CHAP. III.

Of direct North Dials.

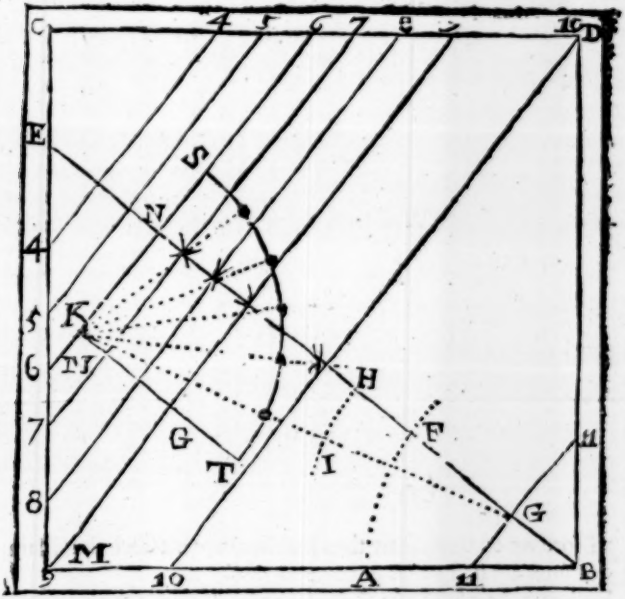
A Direct North Dial is the ſame with a Direct South Dial; for, if you take a South Dial and turn it upſide down, cauſing the Stile or Cock to point upwards, as the Cock of the South doth downwards; and leaving out the hours near the Meridian, in theſe Northern Latitudes; as the hours of 9, 10, 11, and 12 at night, and 1, 2, and 3 in the morning, all which time the Sun is under the Horizon. I ſay a South Dial ſo diſpoſed, and fixed againſt a direct North Wall, ſhall give you the true hour of the day.

CHAP. IV.

How to draw the hour-lines on a direct Eaſt or Weſt Plain.

A Direct Eaſt or Weſt Plain, is ſuch a Plain as directly lieth open to the Eaſt or Weſt points of the heavens; as the North and South Plains do to the North and South points. To make ſuch a Dial, Upon the Plain C B D M (in ſome convenient place thereof towards the lower part) aſſume the point B, then with the Radius of your line of Chords upon B as a Center, deſcribe the obſcure arch A F, then from

from your Chord take the Complement of the latitude of your place, 38 degrees, 30 minutes, and ſet it from A to F, then from B through F draw the line B E, repreſenting the Equinoctial Circle, which in theſe Plains, (as alſo in a Polar Dial) becomes a ſtreight line. In this line E B aſſume two points, one towards one end, and the other to-



wards the other end of the ſame line, as the points G and N, one for the hour of VI, as N; the other for the hour of XI, as G: through theſe two points N and G, draw two right lines quite through your Plain, perpendicular to the Equinoctial line B E, as in the figure, which two lines ſhall repreſent Eleven and Six of the Clock.

This

This done, upon the point G, with the Radius of your Chord describe an occult arch of a circle H I, and set thereon 15 degrees from H to I, then from G through I draw the line G K, cutting N M in K; on K, as a center, with the Radius of your Chord describe the quadrant K S T, which divide into 6 equal parts in the points ●●●●, through which points and K, draw the lines K●, K●, &c. cutting the Equinoctial E B in ✱✱✱✱ &c. Through these points ✱✱✱ &c. draw right lines quite through your plain perpendicular to the equinoctial, which will be parallel to your lines of VI and XI, and will be the true hours of VII, VIII, IX, and X; then the like distances of VII and VIII set above VI on the other side, and drawn parallel thereto, shall be the true hours of IV and V; and thus have you all the hours of an East Dial truly drawn, which is from four in the Morning till eleven at Noon; and is the same with a West Dial, only naming the hours contrary: for in the East Dial 4, 5, 6, 7, 8, 9, 10, 11 in the Morning, are in the West Dial 8, 7, 6, 5, 4, 3, 2, 1 in the Evening.

The Stile of either of these Dials is a thin plate of Brass made directly of the breadth of the distance between the hours of VI and IX, and must be placed directly perpendicular upon the line of VI, and so is your Dial finished.

CHAP. V.

Of upright declining Plains.

BEfore we come to draw the Hour lines upon a declining Plain, two things are first to be discovered, *viz.*

First, *The height of the Pole above the Plain*, which is the height of the Cock or Stile.

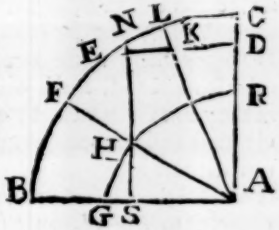
Secondly, *The deflexion*, or distance of the substile from the Meridian or line of twelve of the Clock.

1. *To*

1. *To find the heighth of the Pole above a declining Plain.*

With the radius of your line of Chords, upon A, as a Center, describe the Quadrant A B C, then your Latitude being 51 deg. 30 min. take it out of your line of Chords, and set it from B to E, and draw the line E D parallel to A B, cutting the line A C in D, then with the distance D E, on the Center A, describe the Quadrant G H R. Then supposing your Plain to decline 30 deg. set 30 deg. from B to F, in the Quadrant B E C, and draw the line F A cutting the Quadrant G H R in H, through which point H, draw the line S H N parallel to C A, and cutting the Quadrant B E C in N, so shall the arch C N be the height of the Pole above the Plain, and in this Example contains 32 deg. 37 min.

2. *To find the deflexion, or the distance of the Substile from the Meridian.*



Out of this figure take the distance H S, and set it in the line D E, from D to K; through which point K, draw the line A K L, cutting the Quadrant B C in L; so shall the arch C L be the distance of the Substile from the Meridian: and in this Example will be found to be 21 degrees 42 minutes.

CHAP. VI.

How to draw the Hour-lines upon an upright Plain declining from the Meridian towards the East or West.

WE will here take for Example a South erect Plain, declining Eastward 30 deg.

Having (by the Fifth Chapter of this Book) found the Deflexion of ſuch a Plain to be 21 deg. 42 min. And the height of the Stile (by the ſame Chapter) to be 32 deg. 37 min. we may proceed to draw the Dial in manner following.

With the radius of your line of Chords, on the Center C, deſcribe the Circle X N S W; and in it draw S N through the center C, for the Meridian, or line of 12. Then the deflexion being found to be 21 deg. 42 min. ſet that from N to E, and draw the line E C through the center to G; this line repreſenteth the Subſtilar line of your Dial, upon which line the Stile or Cock muſt ſtand. Alſo out from your line of Chords take 32 deg. 37 min. the height of the Stile, and ſet that diſtance from E to H, and draw the line C H for the Stile of your Dial; ſo ſhall the Triangle E C H be the true pattern for the Cock of your Dial.

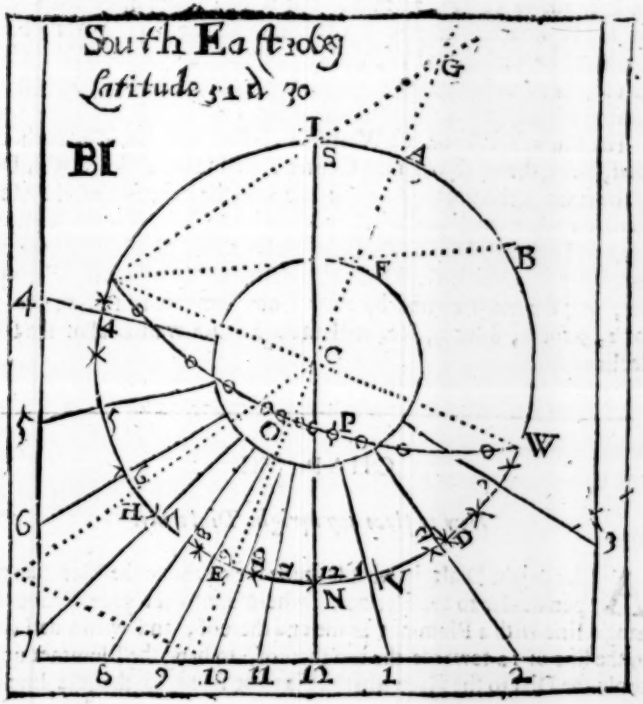
The Subſtilar line E G being drawn, draw the line X W through the center C, and perpendicular to E G. This done, take the diſtance E H, (which is equal to the Stiles height) and ſet that diſtance from A to B, and from W to D. Likewiſe take the diſtance from W to B, and ſet it from B to I. Theſe three points I B, and D, being found in the circumference of the Circle X N S W, lay a ruler from X to I, and it will cut the ſubſtilar line E C being extended in the point G, which is the Center upon which the Equinoctial Circle muſt be deſcribed. Again, a Ruler laid from X to B, will cut the ſubſtilar line in F; and a Ruler laid from X to D, will cut the ſubſtilar in O. Now if you ſet one foot of your Compaſſes in G, and extend the other to X or W, you may deſcribe the Equinoctial Circle X O W, which (if you have not erred in your former Work) will paſs exactly through the point O in the ſubſtilar line before found. In the next place, if you lay a Ruler from F to N, it will cut the Equinoctial Circle in P, and a Ruler laid from C to P, will cut the Dial Circle in V.

Theſe things being performed, the next thing is to draw the hour lines, which will be eaſily effected, if you obſerve the former directions.

Firſt, From the point V laſt found, begin to divide your hour Circle into 24 equal parts (or only one half of it into 12 parts) which you may do by taking 15 deg. out of your line of Chords, and

ſet

ſet that diſtance on both ſides of V at the marks * ** &c. ſo many times as the Plain is capable of hours.



This done, If you lay a Ruler on the Center C, and every of theſe points * * * * &c. you ſhall divide the equinoctial Circle into 12 unequal parts in the points ●●●● &c. Now a Ruler laid from F to every of theſe unequal points ●●●● &c. will divide the hour-circle into 12 other unequal parts marked with 4. 5. 6. 7. 8. 9. 10. 11. 12, 1. on the one ſide of V, and with 2, 3. on the other ſide of V.

Laſtly, A Ruler laid from C to the ſeveral points 4. 5. 6. 7. 8. 9.10.11.12.1.2.3. and lines drawn by the ſide thereof, they ſhall be the true hour lines belonging to ſuch a declining Plain of 30 deg. in the Latitude of 51 deg. 30 min.. But if you deſire more hours then 12, the Equinoctial may be divided into more unequal parts, being continued beyond X and W, and if you will, quite round the whole Circle, but that is needleſs, without you would make 4 Dials in the making of one, as you may eaſily do. For,

The hours that are on the Weſt ſide of the Meridian of a South-eaſt Dial, being drawn through the Center, will make a North-weſt Dial of the ſame declination. And the hours on the Eaſt ſide of the Meridian of a South-weſt Dial, being drawn through the Center, will produce a North-eaſt Dial of the ſame declination. And again, the real hour lines of a South-eaſt Dial being drawn on the other ſide of the paper, and the hours named by their Complements to 12, that is, 10 for 2, 9 for 3, 8 for 4, &c. will make a South-weſt Dial of the ſame declination.

CHAP. VII.

How to place any upright Dial truly.

ALL upright Dials, in what latitude ſoever, have the Meridian perpendicular to the Horizon; wherefore to ſet your Dial exact, hang a line with a Plummet at the end thereof, and with a nail fixed in the line of 12 towards the top thereof, to hang the Plummet upon, apply the Dial to the place where it is to be fixed, ſo that the line and Plummet may hang juſt down upon the line of 12, neither inclining on one ſide or the other; the Dial thus fixed, if the declination were truly taken, and the Dial rightly made by the former directions, ſhall at all times (the Sun ſhining upon it) give you the true hour of the day.

CHAP. VIII.

How to inſert the half and Quarters of hours in all Dials.

THe halfs and quarters of hours are drawn in all Plains by the ſame rules, and the like reaſon, that the hours are inſerted. Therefore take notice that if you would inſert the half hours into any Dial, you muſt divide your Equinoctial Circle into 24 equal parts in ſtead of 12, and if you would inſert the quarters, then you muſt divide it into 48 parts, and then proceed in all reſpect, as you did for the whole hours.

CHAP. IX.

How to find the declination of any upright Wall.

THe declination of a Plain is an arch of the Horizon comprehended between the Pole of the Plains Horizontal line, and the Meridian of the place.

To find this declination, two obſervations muſt be made, the Sun ſhining, and both at one inſtant of time (as near as may be.) The firſt is the Horizontal diſtance of the Sun from the Pole of the Plain. The ſecond is the Suns Altitude.

Firſt, to find the Horizontal diſtance. Apply the ſide of a Quadrant to your plain, holding it (as near as may be) horizontal, that is to ſay, level; then holding up a thred and plummet, which muſt hang at full liberty, ſo that the ſhadow of the thred may paſs directly through the center of the Quadrant, then diligently note through what degree of the Quadrant the ſhadow paſſed, and count thoſe degrees from the ſide of your Quadrant which is perpendicular to the Plain, for thoſe degrees are the Horizontal diſtance.

Secondly, At the ſame inſtant, take the Suns altitude, theſe two being heedfully taken, will help you to the Plains declination by the rules following.

By

By the 17 or 18 Chapters of the ſecond Book find the Suns Azimuth. Then obſerve whether the Sun be between the Pole of the Plains Horizontal line and the North or South points, or not.

If the Sun be between them, add the Azimuth and Horizontal diſtance together, and the ſum of them is the declination of the Plain.

If the Sun be not between them, ſubſtract the leſſer of them from the greater, and the difference ſhall be the declination of the Plain. Theſe rules ſhew you the quantity of your Plains declination. But,

CHAP. X.

Shewing how to know whether your Plain decline from the Meridian towards either the Eaſt or Weſt.

YOu muſt take notice in your obſervation, that if the Meridian point fall between the Azimuth and the Pole of the Plains Horizontal line, then doth the plain decline to the Coaſt contrary to that wherein the Sun is; that is to ſay, if the Sun be to the Eaſtward of the Meridian, the plain declines to the Weſtward: But if the Meridian point be not between the forementioned diſtance and the Pole of the Plain, then doth the Plain decline to the ſame Coaſt in which the Sun was in the time of obſervation.

CHAP. XI.

Concerning Polar Dials.

A Polar Dial is made in all reſpects as an Eaſt or Weſt Dial is made, only the line of 6 a Clock in the Eaſt or Weſt Dial, is 12 a Clock in the Polar Dial, the hour of 7 is 1, of 8 is 2, of 9 is 3, of 10 is 4, and of 11 is 5. Alſo the hour of 5 in the Eaſt or Weſt Dial, is 11 in the Polar, of 4 is 10, of 3 is 9, of 2 8, of 1 is 7, &c. The Cock of this Dial is a plate of Iron or Braſs made of the breadth be-

between 12 and 3 a Clock, and ſet perpendicular upon the line of 12, as in the Eaſt or Weſt Dial it is upon the line of 6. In theſe Dials the Equinoctial line is to lie parallel to the Horizon, and not to be elevated according to the complement of the Latitude of the place, as in the Eaſt or Weſt Dial it is.

CHAP. XII.

Concerning Equinoctial Dials.

AN Equinoctial Dial is of all other Dials, the moſt eaſie to make, for if you deſcribe a Circle, and divide it into 24 equal parts, and draw lines from the Center through every one of thoſe equal parts, the lines ſo drawn ſhall be the true hour lines.

For the Stile of theſe Dials, it is no other but a ſtreight Wyre of any length ſet perpendicular in the Center of the Circle, whoſe ſhadow ſhall give the true hour of the day.

CHAP. XIII.

Of ſuch Plains as decline very far from the Eaſt or Weſt towards the Meridian, as 75, 80. or 85, deg. above which Plains the Pole hath ſmall Elevation.

SUch Plains as decline above 60 degrees, the hour lines will come very cloſe together, ſo that if they be not extended very far from the center, there will be no ſenſible diſtance between hour and hour.

To remedy this inconvenience, there are ſeveral ways, I will inſtance only in one, which is familiar and eaſie, and that is this.

When you have drawn your Dial on a large ſheet of Paper, fix it on ſome large Table or ſmooth Floor of a Room, if the Dial you are to make be very large, as 5, 6, or 7 foot ſquare, then by the ſide of

of a long Ruler laid to the Center and every hour-line, as alſo to the Stile and Subſtile, draw lines to the full extent of the Table or Flower, and you ſhall find them to be of a competent largneſs. Then according to the bigneſs of your Plain cut off the hours, Stile, and Subſtile, leaving the Center quite out, and your Work is finiſhed.

CHAP. XIV.

Concerning Declining, Reclining, and Inclining Dials.

WE ſhould now ſhew the manner of drawing hour-lines upon declining, reclining, and inclining Plains, of which there are ſeveral varieties, and many cautions, which in this place, and at this time, would be too many to enumerate: but if this which hath been already delivered concerning Upright decliners ſhall be kindly accepted, it ſhall animate me to do the like for all other Plains whatſoever.

ALL ſorts of Inſtruments belonging to the Art of Navigation, are to be ſold by *John Sellers* living at the Sign of the *Mariners Compaſs* and *Sphere* at the *Hermitage* Stairs in *Wapping*; where you may be alſo inſtructed in the uſe of any of them, by the ſaid *John Sellers*.

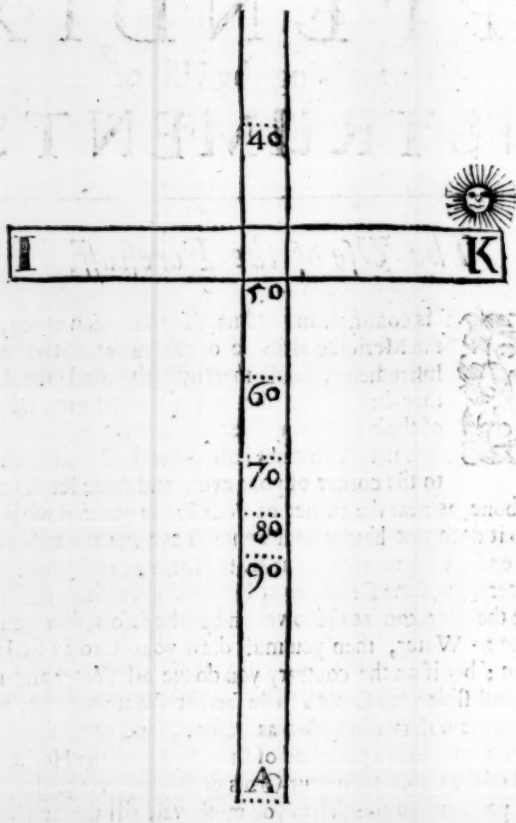
AN APPENDIX, Containing the Use of INSTRUMENTS.

The Use of the Forestaff.

IT is common and ordinary for Sea-men at Sea, to take the Meridian altitude of the Sun and Stars with this Instruthent, and thereby they find the Latitude that they are in; the which to perform, take notice of these following Precepts and Examples.

First, You must hold the end of your Staff, as A, to the corner of your eye; and there let it rest upon your Eye-bone, as near the corner of your eye as you can with convenience, so it doth not hinder your sight: Then you are to look up to the upper end of your Cross, as at K, for the Sun, and you are to look at the lower end of the Cross, as at I, for the Horizon: but if you cannot see the Horizon at the lower end of the Cross, but you do see all Skie and no Water, then you must draw your Cross a little nearer to your eye; but if on the contrary you do see all Water and no Skie, then you must slide your Cross a little farther from your eye, and then you must make observation again as before, and then if you see the center of the Sun at the upper end of the Cross, and the Horizon at the lower end of the Cross, then your Cross doth stand as it ought and that is all that you have to do: Then you must wait till the Sun be on the Meridian, and you must make Observation again as oft as your judgment shall think fit, and as you find the Sun to rise, you must draw your Cross a little nearer to your eye; but if the Sun be fallen, then you

The Figure of the Forestaff.



will not see the Horizon, for the Water will hide it from you, and in such a case as this you must not alter your Cross, but look on that line on your Staff that your Cross doth belong to, and those degrees and minutes

minutes that the Croſs doth ſtand at, is the Suns Meridian altitude.

Thus I have ſhewed you how to take an Obſervation by the *Foreſtaff*: The next thing that followeth in courſe, will be to ſhew you how to work your Obſervation; which to do, take notice of theſe following Rules.

To work your Obſervation.

If the Sun hath North Declination, and be on the Meridian to the Southwards of you, then you muſt ſubſtract the Suns Declination from your Meridian altitude, and the remainer is the heighth of the Equinoctial, or the complement of the Latitude North.

But if the Sun hath South Declination, you muſt add the Suns Declination to your Meridian altitude, and the ſum is the heighth of the Equator, or the complement of the Latitude North.

If the Sun hath North Declination, and be on the Meridian to the Northwards, then add the Suns Declination to your Meridian altitude, and the ſum is the heighth of the Equator, or the complement of the Latitude South, if the ſaid ſum doth not exceed 90 deg. but if it doth exceed 90 deg. you muſt ſubſtract 90 deg. from the ſaid ſum, and the remainer is your Latitude North.

If the Sun hath South Declination, and be to the Northwards at Noon, you muſt then ſubſtract the Suns Declination from his Meridian altitude, and the remainer is the complement of your Latitude South.

When the Sun hath no Declination, then the Meridian Altitude is the complement of the Latitude.

If the Sun be in the Zenith, and if at the ſame time the Sun hath no Declination, then you are under the Equinoctial.

But if the Sun hath North Declination and in the Zenith, then look how many deg. and min. the Declination is, and that is the Latitude that you be in, North.

But if your Declination be South, then you are ſo much in South Latitude.

If you obſerve the Sun or a Star upon the Meridian beneath the Pole, then add your Meridian altitude to the complement of the Sun or Stars Declination, and the ſum is the heighth of the Pole.

Rules for Obſervation in North Latitude.

Admit I am at Sea, and I obſerve the Suns Meridian altitude to be

42 deg. 20 min. and at the same time the Suns Declination is 10 deg. 10 min. North, I demand the Latitude that I am in.

The Meridian altitude		42 deg.	20 min.
The Declination North	Subst.	10	10
The complement of the Latitude		32	10
		90	00
The Latitude that I am in		57	50 *North*

Admit a Ship at Sea the 22 of *May*, *Anno* 1668; and I find the Suns Meridian altitude to be 65 deg. 10 m. I demand the Latitude.

The Meridian altitude		65 deg.	10 min.
The Declination North	Subst.	22	15
The complement of the Latitude		42	55
		90	00
The Latitude that I am in		47	5

Admit a Ship at Sea the 27 day of *Nov. An.* 1687. and I find the Suns Meridian altitude to be 26 deg. 30 min. I demand the Latitude that I am in.

The Meridian altitude		26 deg.	30 min.
The Declination South	Add	22	44
The complement of the Latitude		49	14
		90	00
The Latitude that I am in		40	46

Admit a Ship at Sea the 25 day of *April*, *An.* 1665. and I find the Suns Meridian altitude by observation to be 58 deg. 45 min. I demand the Latitude that I am in.

The Meridian altitude		58 deg.	45 min.
The Declination North	Subst.	16	31
Complement of the Latitude		42	14
		90	00
The Latitude I am in		47	46

Admit a Ship at Sea the 12 day of *June*, *An.* 1669. and I find the Suns Meridian altitude by observation to be 80 deg. 35 min. *North*. I demand the Latitude that I am in.

The

The Meridian altitude		N. 80 deg.	35 min.	
The declination North	Add	23	31	
		104	06	
		90	00	
The Latitude that I am in		14	60	North.

Admit a Ship at Sea the 22 of *August*, *Anno* 1671. and the Suns Meridian altitude was observed to be 85 deg. 15 min. *North*, I demand the Latitude that I am in.

The Meridian altitude		85 deg.	15 min.	
The Declinrtion North	Add	08	17	
		93	32	
		90	00	
The Latitude that I am in		03	32	North.

Admit a Ship at Sea the 20 of *June*, *Anno* 1657. and the Suns altitude was 66 deg. 45 min. *North*, I demand the Latitude that the Ship is in.

The Meridian altitude		66 deg.	45 min.	
The Declination North	Add	23	15	
		90	00	
		90	00	
The Ship is under the Equioctial		00	00	

Rules for observing the Stars.

Admit I am at Sea, and I observe the *Bulls Eye* upon the Meridian, and I find his Meridian altitude to be 50 deg. 30 min. I demand the Latitude that I am in.

The Declination of this Star is		15 deg.	46 min.	*North.*
The Meridian altitude		50	30	
The Declination North,	Subst.	15	46	
Complement of the Latitude		34	44	
		90	00	
The Latitude I am in		55	16	*North.*

Admit I am at Sea, and I observe the bright Star in the *Great Dogs* Mouth, and I find his Meridian altitude to be 35 deg. 45 min. I demand the Latitude that I am in.

The

The Declination of this Star is		16 deg.	15 min. *South*
The Meridian altitude		35	45
The Declination South	Add	16	15
The heighth of the Equator		52	00
		90	00
The Latitude that I am in		38	00

Rules for Obſervation in South Latitude.

Admit a Ship at Sea the 10 day of *May*, *Anno* 1674. and I find the Suns Meridian altitude by obſervation to be 62 deg. 00 min. *North.* I demand the Latitude that the Ship is in.

The Meridian altitude North		62 deg.	00 min.
The Declination North	Add	20	08
The complement of the Latitude		82	08
		90	00
The Latitude that the Ship is in		07	52 South.

Admit a Ship at Sea the 15 day of *January*, *Anno* 1692. and in Longitude 150 deg. *East*, and I find the Meridian altitude by obſervation to be 58 deg. 45 min. *North.* I demand the Latitude that the Ship is in.

The Declination in the Meridian of *London* for the 15 of *January* as aboveſaid, is 18 deg. 57 min. the daily difference in Declination at this time is 15 min. therefore if you look in the Table of Proportion, you will find the proportional minutes to be 6 min. which you muſt add to the declination in the Meridian of *London*, and the ſum will be the true declination for the Longitude of 150 deg. Eaſt, which is 19 deg. 03 min.

The Meridian altitude North,		58 deg.	45 min.
The Declination South,	Subſt.	19	03
The complement of the Latitude		39	42
		90	00
The Latitude that the Ship is in		50	18 South.

Admit a Ship at Sea the 12 day of *July*, *Anno* 1673. and I find the Suns Meridian altitude to be 66 deg. 52 min. *North.* I demand the Latitude.

The

The Meridian altitude North,	66 deg.	52 min.
The Delination North, Add	20	14
The complement of the Latitude	87	06
	90	00
The Latitude required South	02	54

Admit a Ship at Sea, the Suns declination being 15 deg. 30 min. *South*, and the Suns Meridian altitude 80 deg. 45 min. *South*, I demand the Latitude that the Ship is in.

Anſwer, 06 deg. 15 m. *South*.

Admit a Ship at Sea, the Suns Declination being 11 deg. 14 min. *South*, and the Suns Meridian altitude 79 deg. 38 min. *South*, I demand the Latitude.

Anſwer, The Ship is in Latitude 00 deg. 52 min. *South*.

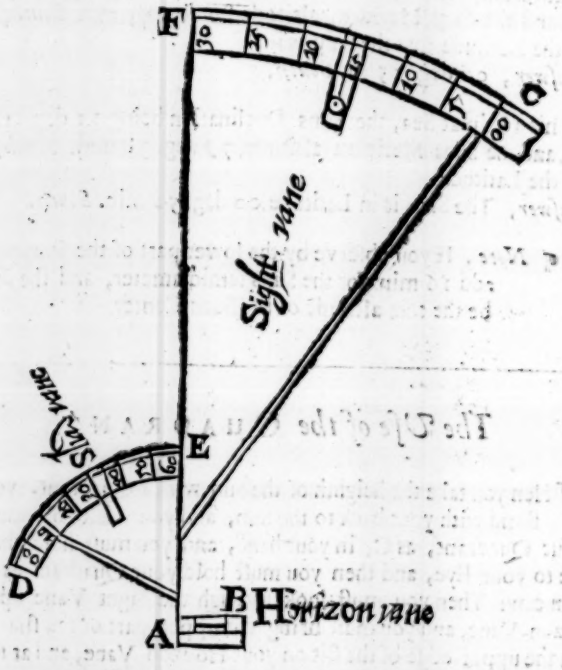
¶ *Note*, If you obſerve by the lower part of the Sun, you muſt add 16 min. for the Suns ſemidiameter, and the ſum will be the true altitude of the Suns Center.

The Uſe of the QUADRANT.

WHen you take the heighth of the Sun with a Quadrant, you muſt ſtand with your back to the Sun, and you muſt hold the handle of your Quadrant, as C, in your hand, and you muſt hold the Sight-Vane to your Eye, and then you muſt hold your Quadrant as upright as you can: Then you muſt look through the Sight Vane upon your Horizon-Vane, and you muſt bring the upper part of the ſhade to lie upon the upper edge of the ſlit on your Horizon Vane, and at the ſame time you muſt look for the Horizon through the ſlit of your Horizon Vane: But if you cannot ſee the Horizon, but you do ſee all Skie and no Water, then draw your Sight Vane a little lower down towards C; But if you ſee all Water and no Skie, then put your Sight Vane a little higher up towards F, and when you have done ſo, obſerve again, and then if you ſee the ſhade lie upon the upper part of the ſlit on the Horizon

rizon Vane, and you at the ſame time do ſee the Horizon through the Sight Vane, then that is all that you have to do: Then you muſt wait till the Sun be on the Meridian, and you muſt tend the Sun, and make obſervation as often as your judgment ſhall think fit: But if the Sun

The Figure of the Quadrant.



be fallen, then when you do go to obſerve again, you will not ſee the Horizon for the Water will hide it from you, and then you muſt not alter your Vanes; but you muſt let them ſtand as they were, and leave off obſerving: Then look what degrees do ſtand by the upper edge

edge of your ſhade Vane, which note, and look likewiſe what degrees ſtand againſt your ſight, by your ſight Vane; which add to the former degrees noted by the ſhade Vane, and their ſum is the diſtance from the *Zenith* to the upper edge of the Sun, to which ſum if you add 16 min. which is the Suns ſemidiameter, you will have the true diſtance of the Suns center from the *Zenith*, or the complement of the Meridian altitude: for if you obſerve by the upper part of the ſhade, then it is the upper limb of the Sun that gives the ſhade: But if you obſerve by the lower part of the ſhade, then it is the lower limb of the Sun that gives the ſhade. Therefore, if you obſerve by the upper part of the ſhade, you muſt add 16 min. but if you obſerve by the under part of the ſhade, you muſt ſubſtract 16 min. to or from what your Inſtrument gives, and the ſum or difference is the true diſtance of the Suns center from the Zenith.

Thus I have ſhewed you how to take an Obſervation with the *Quadrant*, I come now to ſhew you how to work your Obſervation. The difference that there is in working of an Obſervation taken by the *Foreſtaff* and the *Quadrant*, is only this. By the *Foreſtaff* you do take the altitude, but by the *Quadrant* you do take the complement of the altitude, or the diſtance of the Sun from the *Zenith*, but the altitude is the diſtance of the Sun from the Horizon, therefore if you do ſubſtract the complement of the altitude from 90 deg. the remainer will be the altitude which you muſt uſe, as you were ſhewed in the uſe of the *Foreſtaff*.

But becauſe it is uſual to work Obſervations that are taken by the Quadrant, by the complement of the Suns Meridian altitude, I will therefore give you ſome general Rules, and afterwards ſome particular Examples, and then I ſhall proceed to what followeth.

If the Sun hath North declination, and you in North Latitude, and the Sun upon the Meridian to the Southwards, then if you add the Suns declination to the Zenith diſtance, or complement of the Suns Meridian altitude, the ſum will be the Latitude that you are in.

But on the contrary, If the Sun hath South declination, you muſt ſubſtract the Suns declination from the Zeniths diſtance, and the remainer will be the Latitude that you are in.

If you be in South Latitude, and the Sun to the Northwards of you, then if the Sun hath South declination, you muſt add the Suns declina-

tion to the Zenith diſtance, and the ſum will be the Latitude that you are in South.

But if the Sun hath North declination, you muſt ſubſtract the Suns declination from the Zenith diſtance, and the remainer will be the Latitude that you are in South.

¶ I might have been more large herein, giving you more general Rules: but if you underſtand thoſe Rules that I have written for the uſe of the *Foreſtaff*, you cannot err in uſing your *Quadrant*.

Admit a Ship at Sea the 10 day of *April*, *Anno* 1668. and I find the upper limb of the Sun to be diſtant from the Zenith 34 degrees 47 minutes; the Sun being upon the Meridian, I demand the Latitude that I am in.

Rules for Obſervation in North Latitude.

		deg.	m.
Complement of Meridian altitude		34	47
The Suns Semidiameter	add	00	16
Diſtance of Suns center from Zenith		35	03
Declination North	add	11	55
Latitude that the Ship is in		46	58

A Ship at Sea the 14 of *Auguſt*, *Anno* 1672, and I find the Complement of the Suns Meridian altitude by obſervation to be 28 deg. 48 min. *South*, I demand the Latitude that the Ship is in.

		deg.	m.
Complement of Meridian altitude		28	48
Suns Semidiameter	add	00	16
Diſtance of Suns center from Zenith		29	04
Declination North	add	10	52
Latitude that the Ship is in		39	56

Admit a Ship at Sea the 13 of *September*, *Anno* 1674, and I find the Complement of the Suns Meridian altitude by obſervation to be 47 deg. 35 min. I demand the Latitude that I am in.

Com-

Complement of Meridian altitude		47 deg.	35 m.
Suns Semidiameter	add	00	16
Diſtance of Suns center from Zenith		47	51
Declination South	ſubſtract	00	13
Latitude that the Ship is in		47	38

Admit a Ship at Sea the 5 day of *November*, *Anno* 1665. and I find the Complement of the Suns Meridian altitude by obſervation to be 52 deg. 00 min. I demand the Latitude that the Ship is in.

Complement of Meridian altitude		52 deg.	00 m.
Suns Semidiameter	add	00	16
Diſtance of Suns center from Zenith		02	16
Declination South	ſubſtract	18	45
Latitude that the Ship is in		33	31

Admit a Ship at Sea the 27 of *May*, *Anno* 1692. and I find the Sun to be to the Northward of me; and I find the complement of his Meridian altitude by Obſervation to be 10 deg. 15 min. I demand the Latitude that the Ship is in.

Suns Declination North		22 deg.	49 m.
Complement of Meridian altitude		10	15
The Suns Semidiameter	add	00	16
The true Zenith diſtance	ſubſt.	10	31
Latitude that the Ship is in		12	18 N.

Admit a Ship at Sea the 29 day of *June*, *Anno* 1695. and the Sun being upon the Meridian, I find by obſervation that the upper limb of the Sun is 6 deg. 42 min. to the Northwarth of my Zenith, I demand the Latitude that I am in.

Suns Declination North		22 deg.	26 m.
Suns Semidiameter	add	00	16
Suns ſupream marg. diſt. from Zenith		06	42
Diſtance of Suns center from Zenith		06	58
Latitude that the Ship is in		15	28

A Ship at Sea the 21 of *July*, *Anno* 1682. and I am in Longitude 165 deg. *Weſt*, and the Sun being upon the Meridian, I find by obſervation that the ſupream margine of the Sun is 16 deg. 45 min. to the Northward of my Zenith, I demand the Latitude that the Ship is in.

Declination North		18 deg.	15 m.	
Proportional minutes	ſubſt.	00	06	
Suns Declination in the Merid. given		18	09	
Suns ſupream Marg. diſt from Zenith		16	45	
Suns Semidiameter	add	00	16	
Suns center diſtant from Zenith		17	01	
Latitude that the Ship is in		01	08	N.

Rules for obſervation in South Latitude.

Admit a Ship at Sea the 15 day of *July*, *Anno* 1691. and I am in Longitude 150 deg. *Eaſt*, and the Sun being upon the Meridian, I find the Complement of his Meridian altitude by obſervation to be 48 deg. 28 min. *North*, I demand the Latitude that the Ship is in.

Complement of Meridian altitude		48 deg.	28. m.	
Suns Semidiameter	add	00	16	
Suns center diſtant from Zenith		48	44	
Declination North	ſubſt.	19	47	
Latitude that the Ship is in		28	57	*S.*

Admit a Ship at Sea the 25 of *October*, *Anno* 1685, and in Longitude 120 deg. Weſt, and the Complement of the Suns Meridian altitude by obſervation is 27 deg. 29 min. North, I demand the Latitude that the Ship is in.

Complement of Meridian altitude		27 deg.	29 m.	
Suns Semidiameter	add	00	16	
Suns center from the Zenith		27	45	
Declination South	add	15	46	
Latitude that the Ship is in		43	31	*S.*

Admit a Ship at Sea the 25 of *December*, *Anno* 1694. and I find the Sun upon the South part of the Meridian, and I find by obſervation that the complement of the Suns Meridian altitude is 15 deg. 10 m. I demand the Latitude that the Ship is in.

Comple-

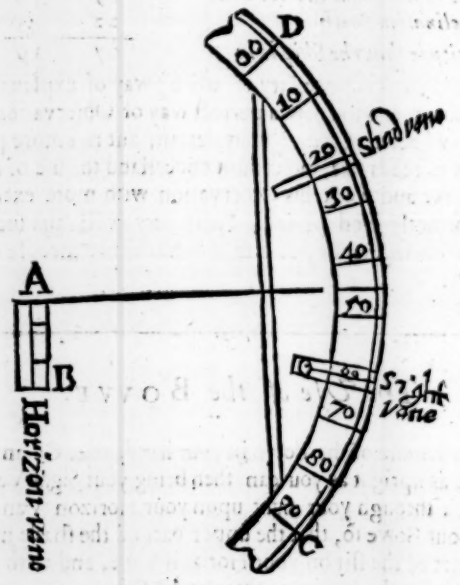
Complement of Meridian altitude		15 deg.	10 m.
Suns Semidiameter	add	00	16
Suns center from the Zenith		15	26
Declination South		22	45
Latitude that the Ship is in		07	19 S.

Thus much I thought necessary to add by way of explanation of the foregoing Tables, and to shew a perfect way of Observation. I might, I confess, have been more copious herein, but not more plain; and that person who reads this, and cannot understand the use of the Tables, and how to take and work his Observation with more exactness than hath been formerly used, I say, I may very well rank such a person amongst the dis-ingenious, as a man unfit to intermeddle with things of this nature.

The Use of the BOWE.

TAke the handle of the Bowe in your hand, *viz.* C, and hold your Bowe as upright as you can then bring your Sight Vane to your eye, and look through your sight upon your Horizon Vane, and you must hold your Bowe so, that the upper part of the shade may lie upon the upper part of the slit on your Horizon Vane, and at the same time you must look for the Horizon, through the slit of your Horizon Vane: But if you cannot see the Horizon, but you do see all skie and no water, you must then draw your sight-Vane a little lower down towards C. But if on the contrary, you do see all water and no skie, then slide your sight Vane a little higher up towards D, and then make observation again, and then if the upper part of the shade doth lie upon the upper part of the slit, and at the same time you do see the Horizon through your sight, and so through the slit of the Horizon Vane, then that is all that you have to do. Then you must wait, and make observation as often as your judgment shall think fit, until such time as the Sun be on the Meridian; and if the Sun be to the Westwards of the Meridian, then you will perceive the Sun to be fallen, and then you will not see the Horizon when you observe, for the water will hide it from you, and then you have done observing for that time. Then

Then look what degrees and minutes do ſtand againſt your ſight at your ſight Vane, which note, and look likewiſe what degrees do



ſtand by the upper part of the ſhade Vane; which ſubſtract from the former degrees noted by the ſight Vane, and the remainer is the Suns Meridian altitude, or the diſtance of the upper part of the Sun from the Horizon, from which if you ſubſtract 16 minutes, which is the Suns Semidiameter, the remainer will be the diſtance of the Suns center from the Horizon, or the true Meridian altitude.

Now for to work your Obſervation, after you have the true Meridian altitude, you are to follow the ſame method that I have given you for the *Foreſtaff*.

The Uſe of the NOCTURNAL.

SEt the Tooth to the day of the Moneth, and hold it faſt ſtanding in that ſort: Then lift up the Inſtrument, and hold it as upright as you can, only bow the uppermoſt part thereof ſo much towards you, until you may ſee the North Star through the hole in the center of the Nocturnal. Now when you ſee the North Star through the hole, then wind the Rule about, until by the cyphered edge of the Rule you may ſee the firſt of the Guards on the *Little Bear*; now if at the ſame time you ſee the North Star through the hole, and the firſt of the Guards on the *Little Bear*, by the edge of the Rule, then that is all that you have to do at that time. Then look by the edge of the Rule on the Hour Circle, and you will ſee the true hour of the Night. And ſee what point of the Compaſs the edge of the Rule ſtandeth by, and that point ſheweth you the bearing of the Guard Star from the North Star.

Example.

Admit the 10 *day of* February *I obſerve at* 7 *a clock in the evening, I demand the bearing of the* Guard Star *from the* North Star.

If you look on the backſide of the Nocturnal, you will find the edge of the Rule to ſtand againſt the North-eaſt point, which is the point of Bearing deſired.

¶ You are to take notice that you muſt alwayes hold the Foreſide of the Nocturnal next your face.

Admit I obſerve the heighth of the North Star *to be* 42 *deg.* 10 *min. and I find by the Nocturnal at the ſame time that it is a* N E *by* N *Guard, I demand the height of the Pole.*

The Table that is in the 87 page of the *Seamans Kalender* ſheweth, that when it is a *N E by N* Guard, the North Star is 1 deg. 3 min. above the Pole; therefore I ſubſtract this 1 deg. 3 m. from 42 d. 10 m. and the remainer is 41 d. 7 m. which is the height of the Pole deſired.

Admit I obſerve the height of the North Star to be 45 *deg.* 22 *m. and I find by the Nocturnal at the ſame time, that it is a* S S E *Guard, I demand the height of the Pole.*

By

By the Table abovesaid, I find that with a *S S E* Guard the North Star is 2 deg. 29 min. under the Pole, therefore I add this 2 deg. 29 min. to 45 deg. 22 min. and the sum is 47 deg. 51 min. which is the heighth of the Pole desired.

The Use of GUNTERS LINES *in* NAVIGATION.

A Ship being in the Latitude of 43 deg. 30 min. North, she sails *S W b S.* 104 leagues, I demand the Latitude that she is in, and the departure from the Meridian.

Set one foot of your Compasses in 8 points, and extend the other to 3 points, then set one foot in 104 in the line of numbers, and extend the other backward, and it will fall in 58 leagues, which is the departure from the Meridian: Then set one foot in 8 points, and extend the other to 5 points; then set one foot in 104 number, and extend the other backward, and it will fall in 86 Leagues, which is the difference of Latitude

86 (4 d. 18 m.	43 d. 30 m.	*Latitude departed*
20	4 18	
	39 12	*Latitude the Ship is in.*

A Ship being in the Latitude of 50 *deg.* 20 *m. North, sails* NNW 87 *leagues, I demand the Latitude that she is in, and the departure from the Meridian.*

Set one foot in 8 p. and extend the other to 2 p. then set one foot in 87 N. and extend the other backward, and it will fall in 33 leagues, which is the departure from the Meridian. Then set one foot in 8 p. and extend the other to 6 p. then set one foot in 87 N. and extend the other backward, and it will fall in 80 leagues, which is the difference of Latitude

80 (4 d. 00 m.	50 d. 20 m.	*Latitude departed*
20	4 00	
	54 20	*Latitude the Ship is in.*

A

A Ship being in the Latitude of 51 *deg.* 15 *m. North, ſhe ſails* SEbS, *until ſhe be in the latitude of* 46 *deg.* 45 *min. I demand the diſtance run, and the departure from the Meridian.*

Set one foot in 8 p. and extend the other to 5 p. then ſet one foot in 90 N. and extend the other forwards, and it will fall in 109 leagues, which is the diſtance run.

Set one foot in 5 p. and extend the other to 3 p. then ſet one foot in 90 n. and extend the other backward, and it will fall in 60 leagues, which is the departure from the Meridian.

A Ship being in the latitude of 48 *deg.* 00 *m. North, ſhe ſails between the South and the Eaſt until ſhe be in the latitude of* 42 *deg.* 30 *m. and till her diſtance run be* 134 *leagues, I demand the courſe that ſhe hath ſailed, and the departure from the Meridian.*

Latitude departed	48 deg.	00 min.
Latitude ſhe is in	42	30
Difference of Latitude	05	30
Leagues	110	

Set one foot in 134 N. and extend the other to 110 N. then ſet one foot in 90 ſines, and extend the other backward, and it will fall in 55 deg. 00 min. ſines, which is the complement of the courſe; therefore the courſe is 35 deg. 00 min. from the South Eaſtwards.

Set one foot in 90 d. ſine, and extend the other to 35 d. ſine, then ſet one foot in 134 N. and extend the other backward, and it will fall in 77 N. which is the departure from the Meridian.

A Travis.

A Ship being in the latitude of 40 *deg.* 00 *m. North, ſhe ſails* SEbS 68 *miles, and then ſails* SWbS 55 *miles, and then ſails* WNW 75 *miles; I demand the courſe and diſtance ſailed from the firſt place of departure.*

Set one foot in 8 p. and extend the other to 3 p. then ſet on foot in 68 n. and extend the other backward, and it will fall in 38 N. which is the Eaſting in the firſt courſe.

Set one foot in 8 p. and extend the other to 5 p. then ſet on foot in 68 n. and extend the other backward, and it will fall in 56 N. which is the Southing in the firſt courſe.

Next, Set one foot in 8 p. and extend the other to 5 p. then ſet one foot in 55 N. and extend the other backward, and it will fall in 45 N. which is the Weſting in the ſecond courſe. Set one foot in 8 p. and

extend the other to 3 p. then ſet one foot in 55 n. and extend the other backward, and it will fall in 30 n. which is the Southing in the ſecond courſe. Set one foot in 8 p. and extend the other to 6 p. then ſet one foot in 75 n. and extend the other backward, and it will fall in 69 n. which is the Weſting in the third courſe. Then ſet one foot in 8 p. and extend the other to 2 p. then ſet one foot in 75 n. and extend the other backward, and it will fall in $28\frac{1}{3}$ n. which is the Northing in the third courſe.

North	*South*	*Eaſt*	*Weſt*
$28\frac{1}{3}$.	56	38	45
	50	114	69
	86	76 *dept.*	114
	$28\frac{1}{3}$		
	$57\frac{1}{3}$ *difference of Latitude.*		

Set one foot in 76 n. and extend the other to $57\frac{1}{3}$ n; then ſet one foot in 45 d. tan. and extend the other backward, and it will fall in 53 deg. 00 min. tan. which is the courſe from the Southweſtward, *viz.* SW 8 deg. Weſt. Set one foot in 90 ſine, and extend the other to 53 d. ſine, then ſet one foot in 76 n. and extend the other forward, and it will fall in 96 n. which is the diſtance run from the firſt place of departure.

x		
57 (2 d. 52 m.	40 d. 00 m.	*Latitude departed*
28	2 52	*diff. of Latit. Sub.*
	37 08	*Latit. the Ship is in.*

A Ship being in the Latitude of 50 *deg.* 10 *m. North, and in Longitude* 5 *d.* 24 *m. Weſt, ſhe ſails firſt* SSE 72 *miles, and then ſails* WSW 45 *miles, and then ſails* E b N 67 *miles, and then ſails* NNE 85 *miles, and then ſails* WSW 40 *miles: now I demand the courſe and diſtance ſailed from the firſt place of departure; likewiſe the latitude and longitude that the Ship is in.*

1 Courſe

1 Courſe	8 p	2 p	72 n	27½ n	East
	8 p	6 p	72 n	66 n	South
2 Courſe	8 p	6 p	45 n	41 n	Weſt
	8 p	2 p	45 n	17 n	South
3 Courſe	8 p	7 p	67 n	65⅓ n	East
	8 p	1 p	67 n	13 n	North
4 Courſe	8 p	2 p	85 n	32 n	East
	8 p	6 p	85 n	78 n	North
5 Courſe	8 p	6 p	40 n	36⅓ n	Weſt
	8 p	2 p	40 n	15 n	South

North	*South*	*East*	*Weſt*
13	66	27½	41
78	17	65⅓	36⅓
	15	32	
91			77⅓
	98	125	
Northing	*Southing*	*Eaſting*	*Weſting*

Southing	98	*Eaſting*	125
Northing	91	*Weſting*	77⅓
Differ. of Latit.	07	*Departure*	47⅓

Set one foot in 47 ⅓ n. and extend the other to 7 n. then ſet one foot in 45 d. tan. extend the other backward, and it will fall in 81 d. 36 m. tan. which is the courſe from the South Eaſtwards, *viz.* E *by* S. ½ E. Set one foot in 90 deg. ſine, and extend the other to 81 deg. 36 m. ſine, then ſet one foot in 47⅓ n. and extend the other forward, and it will fall in 48 n. which is the diſtance run from the firſt place of departure.

The Latitude departed	50 deg.	10 m.
Difference of Latitude	00	07
The Latitud the Ship is in	50	03
	100	13
The middle Latitude	50	6

Set one foot in 90 deg. ſine, and extend the other to 39 deg. 54 m. ſine, then ſet one foot in 47 ½ n. and extend the other forward, and it will fall in 74 n. which is the difference of longitude in miles.

Longitude departed	5 deg.	24 m.	
Difference of Longitude	1	14	
The Longitude the Ship is in	4	10	Weſt.

Note, If you be in Weſt Longitude, and ſail to the Eaſtward, you muſt ſubſtract your difference of Longitude from your Longitude departed, and the remainer is the Longitude that the Ship is in: But if you ſail to the Weſtward, you muſt add your difference of Longitude to the Longitude departed, and the ſum is the Longitude that you are in: But if you be in Eaſt Longitude, then ſailing to the Eaſtward your Longitude increaſeth, and ſailing to the Weſtward your Longitude decreaſeth.

A Ship being in the Latitude of 41 *deg.* 30 *m. North, and in Longitude* 10 *deg.* 20 *m. Eaſt, ſhe firſt ſails* S E *by* S 52 *miles, and then ſails* S S W 63 *miles, and then ſails* E *by* N 47 *miles, and then ſails* N by E ½ E 35 *miles, and then ſails* N N W ¼ W 67 *miles, and then ſails* W N W 73 *miles; Now I demand the courſe and diſtance ſailed from the firſt place of Departure, likewiſe the Latitude and Longitude that the Ship is in.*

	M.	*P.*	*P.*	*N.*	*N.*		*P.*	*P.*	*N.*	*N.*	
S E by S	52	8	3	52	28 ¾	*E*	8	5	52	43	*S*
S S W	63	8	2	63	24	*W*	8	6	63	58	*S*
E by N	47	8	7	47	46	*E*	8	1	47	09	*N*
N E b E ½ E	35	8	5 ⅓	35	31	*E*	8	2 ⅓	35	16 ⅓	*N*
N N W ¼ W	67	8	2 ¼	67	28 ⅓	*W*	8	5 ¾	67	60	*N*
W N W	73	8	6	73	67	*W*	8	2	73	27 ⅓	*N*

North

North	*South*	*East*	*West*
9	43	$28\frac{3}{4}$	24
$16\frac{1}{3}$	51	46	$28\frac{1}{3}$
60		31	67
$27\frac{1}{3}$	101 South	$105\frac{1}{4}$ Easting	$119\frac{1}{3}$ Westing
113 Northing			$105\frac{1}{4}$
101			$13\frac{1}{4}$
12 *diff. Latitude*			*depart. Merid.*

Set one foot in 12 n. and extend the other to $13\frac{1}{4}$ n. then ſet one foot in 45 deg. tan. and extend the other backward, and it will fall in 48 deg. 50 m. tan. which is the courſe from the North Weſtward, *viz. NW* 3 deg. 50 min. Weſt. Set one foot in 90 d. ſine, and extend the other to 48 deg. 50 min. ſine, then ſet one foot in $13\frac{1}{4}$ n. and extend the other forward, and it will fall in $18\frac{1}{4}$, which is the diſtance run from the firſt place of the departure.

Latitude departed	41 deg.	30 m.
Difference of Latitude	00	12
Latitude the Ship is in	41	42
	18	12
Middle Latitude	41	36

Set one foot in 90 deg. ſine, and extend the other to 48 deg. 24 m. ſine, then ſet one foot in $13\frac{3}{4}$ n. and extend the other forward, and it will fall in $18\frac{1}{4}$ n. which is the difference of Longitude in miles.

Longitude departed		10 deg.	20 m.
Difference of Longitude	ſubſt.	0	18
Longitude the Ship is in		10	02

The

The Uſe of GUNTERS LINES *in meaſuring* OF BOARD *and* TIMBER.

ADmit a Board to be 10 *inches broad, and* 20 *foot long, I demand the Content.*

Set one foot in 12, and extend the other to 10, then ſet one foot in 20, and extend the other backward, and it will fall in 16 foot and a half, which is the content of the Board required.

Admit a Board to be 15 *inches broad, and* 27 *foot long, I demand the content.*

Set one foot in 12, and extend the other to 15, then ſet one foot in 27 and extend the other forward, and it will fall in 34 foot, which is the content required.

Admit a Board to be $7\frac{1}{2}$ *inches broad, and* 29 *foot long, I demand the content.*

Set one foot in 12, and extend the other to $7\frac{1}{2}$, then ſet one foot in 29, and extend the other backward, and it will fall in 18 foot; which is the content required.

Admit a Board to be 27 *inches broad, and* 9 *foot and a half long, I demand the content.*

Set one foot in 12, and extend the other to 27, then ſet one foot in $9\frac{1}{2}$, and extend the other forward, and it will fall in $21\frac{1}{2}$ foot; which is the content required.

Admit a piece of Timber to be 8 *inches ſquare, and* 20 *foot long, I deſire to know how many ſquare foot there is contained in this piece of Timber.*

Set one foot in 12, and extend the other to 8, then ſet one foot in 20, and extend that diſtance twice backward, and it will fall in 8 foot 3 quarters, which is the content required.

Admit a piece of Timber to be $9\frac{1}{2}$ *inches ſquare, I demand the content.*

Set

Set one foot in 12, and extend the other to $9\frac{1}{2}$, then ſet one foot in 27, and extend that diſtance twice backward, and it will fall in 17 foot; which is the content required.

Admit a piece of Timber to be 18 *inches ſquare, and* 9 *foot long, I demand the content.*

Set one foot in 12, and extend the other to 18; then ſet one foot in 9, and extend that diſtance twice forward, and it will fall into $20\frac{1}{4}$ foot; which is the content required.

Admit a piece of Timber to be 22 *inches ſquare, and* 35 *foot long, I demand the content.*

Set one foot in 12, and extend the other to 22; then ſet one foot in 35, and extend that diſtance twice forward, and it will fall in 118 foot; which is the content required.

The Uſe of the SECTOR *in Navigation.*

A Ship being in the Latitude of 42 deg. 20 min. North, ſhe ſails *NEbN* 104 leagues, I demand the Latitude that ſhe is in, and the departure from the Meridian.

Firſt take the half of 104, which is 52, from the Line of Lines, then ſet one foot in 90 deg. ſines, and open the Sector till the other foot toucheth 90 deg. ſines on the other part of the Sector, and there let the Sector ſtand; then ſet one foot in 33 deg. 45 m. ſines, and extend the other to 33 deg. 45 m. ſines, and meaſure that diſtance on the line of lines, and it will be 29, the double of it is 58 leagues, which is the departure from the Meridian. Set one foot in 56 deg. 15 min. ſine, and extend the other to 56 deg. 15 min. ſine, and meaſure that diſtance on the line of lines, and it will be $43\frac{1}{2}$, the double of it is 87 leagues, which is the difference of Latitude.

87(4 d. 21 m.
20

42	d. 20	m.	*Latitude departed*
4	21		*Difference* add
46	41		*Latit. the Ship is in.*

A Ship being in the Latitude of 43 *deg.* 10 *min. North, ſhe ſails*

SSW

SSW 87 miles, I demand the Latitude that ſhe is in, and the departure from the Meridian.

Take 87 from the line of lines, and with that diſtance ſet one foot in 90 deg. ſine, and extend the other to 90 deg. ſine, then let the *Sector* ſtand: Then ſet one foot in 22 d. 30 m. ſine, and extend the other to 22 d. 30 m. ſine, and meaſure that diſtance upon the line of lines, and it will be 33 miles, which is the departure from the Meridian. Then ſet one foot in 67 deg. 30 m. ſine, and extend the other to 67 d. 30 m. ſine, then meaſure that diſtance upon the line of lines, and it will be 80 miles, which is the difference of Latitude.

80(1 d. 20 m.	43 d. 10 m.	*Latitude departed*
60	1 20	*Difference* ſubſt.
	41 50	*Latit. the Ship is in*

A Ship being in the Latitude of 51 deg. 15 min. North, ſhe ſails SWbS, until ſhe be in the Latitude of 46 deg. 45 min. I demand the diſtance run, and the departure from the Meridian.

Take 45 from the line of lines, and ſet one foot in 56 deg. 15 min. ſine, and open the Sector till the other foot touch 56 deg. 15 m. ſine, then let the Sector ſtand: then ſet one foot in 90 deg. ſine, and extend the other to 90 deg. ſine, and meaſure that diſtance on the line of lines, and it will be 54, the double is 108 leagues, which is the diſtance run.

Then ſet one foot in 33 deg. 45 min. ſine, and extend the other to 33 deg. 45 m. ſine, and meaſure that diſtance on the line of lines, and it will be 30, and the double is 60 leagues, which is the departure from the Meridian.

FINIS.